EFFECT OF SOWING TIME AND LEVELS OF PHOSPHORUS AND POTASH ON SEED PRODUCTION IN *STYLOSANTHES HAMATA* (L.) CV. VERANO

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CERTIFICATE

This is to certify that the thesis entitled "**Effect of sowing time and levels of phosphorus and potash on seed production in *Stylosanthes hamata* (L.) cv. verano**" submitted in partial fulfilment of requirements for the award of degree of "Doctor of Philosophy in Agricultural Sciences (Agronomy)", of Bundelkhand University, Jhansi, is a record of bonafide research work carried out by Shri Sudhakar Natthuji Mendhe, under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in any other form.

This is also certified that Shri S. N. Mendhe has put in the attendance required under the University's statutes during the course of present investigation.

LUCKNOW

Dated : 21.12.1997

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ABBREVIATIONS USED

cm	Centimeter /s
C.D.	Critical Difference
^{0}C	Degree Cellcius
cv.	cultivar
et. al.	et alia (and associates)
Fig.	Figures
g	gramme /s
dm.	Decimeter
ha	Hectare
m	Meter
Kg	Kilogram /s
mm	millimeter /s
viz.	namely
N.S.	Non significant
-1	per
%	Per cent
q	quintal /s
S.E.m ±	Standard error of mean
i.e.	that is
t	tonne /s
N	Nitrogen
P	Phosphorus
K	Potassium
met.	Meteorological
@	at the rate of
D.A.S.	Days after sowing
Rs	Rupees

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CHAPTER - I

INTRODUCTION

INTRODUCTION

India has about 150 million hectares of wasteland degraded to such an extent that it could support only inferior (devoid of legume) vegetation and growth of range grass cover. Besides poor carrying capacity of the grass cover, these rangelands are also loosing enormous soil through various types and stages of erosion. To improve this situation, Research Institutions and Agricultural Universities are engaged in identifying some suitable tropical legume, which could grow under marginal inputs and situations, improve biomass and its nutritive value, prevent soil erosion and also broaden the soil profile base. Work carried out in this direction leads to the use of a genus *Stylosanthes* in grassland improvement which proved to be the most suitable for growing under such situations.

Stylosanthes is a genus of the subtribe *Stylosanthinae* tribe *Aeschynomeneae*, sub family *Papilionoideae*, and family *Leguminosae* (Pohill and Raven, 1981) with its natural distribution in tropical, subtropical and temperate regions of America, tropical Africa and South-East Asia. It comprises of about 30 species which provide more cultivars for tropical pasture than any other genus. The success introduction of species within this genus may be related to their rather distinctive morphology and to wide interspecific variations in morphological and physiological characteristics (But et. al., 1981).

or Burt

Stylosanthes are widely distributed in between 30^0 North and South of the equator as reported by Burt et. al. (1970). Reports of its occurrance and distribution as well as studies are available from Australia, Phillipines, Burma, Keniya, Nigeria, Ivory Coast, Mexico, Hawai, Fiji, Colombia, Venenzuela, Peru, Brazil, Argentina and India. In India a native species *Stylosanthes mucronata* is naturally occurring in the Peninsular region and has proved its suitability for improvement in productivity and herbage quality under the degraded habitates.

Stylosanthes mostly prefer tropical and subtropical climate with varied edaphic requirements. Most of these species require well drained light soils including marginal impoverish classes. Amongst the five prominent species of *Stylosanthes (Stylosanthes humilis, S. guianensis, S. scabra, S. hamata and S. viscosa), S. hamata* is now found most versatile and adaptive to wide ecological amplitudes. It has been found growing satisfactorily on saline sodic soil with pH as high as 10.5, Calcareous wastelands and revinous areas subjected to high degree of erosion too (Rai and Pathak, 1985).

Verano is a cultivar of *S. hamata* collected in 1965 from Marcaibo Air port Venenzuela (Skerman, 1977) and released in Australia in 1973. It flowers earlier in the growing season and seed can be produced at anytime of the year although the main seeding period is in early autumn. The soil reserves give natural seedling regeneration and replaces the died plants. It is successful in the region receiving 600 mm rainfall (Chatterjee and Das, 1989). It's growth continue during reproductive phase also (Wilaipon et. al., 1979) but impaired in the cool season (Humphreys, 1979). The stem

develops to a maximum level at active flowering and seed setting stages and it is estimated that about 35% of the total biological yield of plant sheds on the ground (Skerman, 1977). It performed as a weak biennial with a mean survival rate of 17 per cent (Gutteridge, 1986) and majority of plants died in their seeding year (Gardener, 1981).

Besides a source of protein rich cattle feed the legume possesses a ability to regenerate eroded shallow granitic soils (Wilaipon et al. 1979) and also extract phosphorus from the soils having low content of total and available phosphorus. Transfer of this efficiency of phosphorus absorption to other legumes and grasses would reduce the fertilizer cost (Minson et al. 1993). It can also serve as N fixer, a cover crop and mixed crop in native pastures. It is drought resistant, capable to smother weeds and rehabilitating worn-out hilly areas (Alferez, 1979).

Profuse seed production and its realization is the major constraint in this crop. To introduce this legume for renovation and improvement of degraded wastelands, large quantity of seed material is required at a reasonable cost. At present, seed requirement of the country is estimated about 1500 tons per annum as against the availability of about 250 to 300 tons, that too in the unorganized sectors in Andhra Pradesh, Dharwad (Hindupur), Kolar and Begapalli Taluka in Karnataka (Singh, 1993; Singh et. al. 1994) where the crop is mostly managed as an annual.

The seed yield is largely determined by the recovery efficiency of the fallen seed on the ground by sweeping the ground surface. Seed dropping and auto seeding are the main problems in seed production management and harvesting of this legume (Humphreys, 1979). Similarly the

seed collection efficiency also dependent up on the nature of ground surface (Singh et. al., 1994).

Sowing time plays an important role in crop husbandary as it influences crop population, growth and canopy structure. The studies conducted on *Stylosanthes* so far indicated that, highest seed yield is obtained by sowing the crop at the onset of growing season. In North-East Thailand early sowings showed significanlty highest seed yield as against the late sowings (Moolsiri et. al., 1980). At Jhansi also stylo sown on 30th June produced higher quantity of seed as compared to latter sowing (Tomar and Dixit, 1988). Similarly, for seed production purpose higher yields are obtained only when it is grown as an annual crop (English and Hopkinson, 1985; Norton et. al., 1992).

Although, *Stylosanthes* plants are efficient in extracting phosphorus from the soil, but also responds well to additional application of phosphorus (Kanodia et. al., 1985; Rai and Pathak, 1985; Khara et. al., 1990; Minson et. al., 1993). Available phosphorus plays a key function in nodulation, phosporelation and other biological processes of the plant.

Potassium helps in translocation of photosynthate from source to sink. It induces tolerance in the plant against biotic and abiotic stresses and photosynthesis. Not much work appears to have been reported on the role of potassium in *Stylosanthes* seed production. The trials conducted so far indicated no significant response (Wickham et. al., 1977) or minor response (Standley et. al., 1990) to potassium. However, it proved more important in the legume persistency of the established cover (Mombiela, 1989).

On the basis of preceeding discussion, it emerged that the information in respect of influence of sowing time, phosphorus and potash application is quite scanty in the world and indigenous literature. Hence a need was felt to understand the seed production activity in this priced and valuable tropical legume under perennial behaviour as well as taking advantage of the soil seed reserve after first year seeding (without sowing in the subsequent year). The present research project entitled "**Effect of sowing time and levels of phosphorus and potash on seed production in *Stylosanthes hamata* (L.) cv. Verano**" was undertaken with the following objectives.

i. To find out suitable sowing time for seed production.

ii. To find out optimum dose of phosphate and potash for seed production.

iii. To work out the economics of seed production for various sowing treatments.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The research work carried out on sowing time and levels of phosphrous and potash on seed production in *Stylosanthes hamata* cv. Verano is very scanty in the country. However, *Stylosanthes* species are reported to be common in wild form in the Southern region of the country (Trimen, 1974). The important findings relavent to the present investigation are reviewed briefly in this chapter.

2.1 Influence of sowing time on plant growth behaviour

Crop plants under different sowing dates are subjected to variable conditions of an environmental factors like solar radiation, photoperiod, temperature and rainfall, which influences their growth. Temperature and photoperiod are the major factors regulating the duration of growth pahses, modify the morphological conditions thus, influences the photosynthetic period and affects dry matter production. Higher temperature over optimum regime enchances respiration losses and restrict biomass accumulation.

2.1.1 Plant population

Studies conducted at Jhansi, Anonymous (1974) reported that broad-casting of *Stylosanthes humilis* in second year, and *Glycine javanica* in the first, in natural grassland dominated by *Sehima nervosum* and

Heteropogon contortus, in pre-monsoon and line sowing in monsoon respectively alongwith 20 kg P_2O_5 ha^{-1} recorded highest germination and plant population (96250 and 49333 plants ha^{-1} for *S. humilis* and *G. javanica* respectively), followed by dibbling in premonsoon (79583 plants ha^{-1} for *S. humilis*).

Edye et. al. (1976) studied nineteen accessions of eight *Stylosanthes* species at Saltbush park, Westwood and Plain view stated that, initial plant density $\geq$ 8 plants m^{-2} is sufficient for satisfactorily sward development in *S. hamata* cv. verano. Further they stated that out of 121 plants of first year, only 16 plants m^{-2} could survive during the second year.

Fisher and Campbell (1977), while studying *S. humilis* reported that, stress during early vegetative phase reduced the plant poputation.

Velayudhan et. al. (1977) observed that, establishement of *S. humilis* in native *Sehima-Heteropogon* grassland was better when sown in the month of July.

Rai and Patil (1984), while testing the effects of line sowing broad-casting, weeding and no weeding on various *Stylosanthes* species, recorded highest mean plant population (60500 plant ha^{-1}) in *S. hamata* during ~~plant~~ first year, which increased to 380500 plant ha^{-1} in the subsequent year.

Anonymous (1985) found that, *S. hamata* introuduced in the native grassland in May end, mid June, June end and mid July, plant density was significantly higher with early sowing (12043 plnats ha^{-1}) over delayed one (7821 plants ha^{-1}).

While studying the effects of three techniques of sowing (broadcasting, dibbling and line sowing) and four times of sowing (May end, mid June, June end and mid July), Anonymous (1986) reported significant co-relation between time of sowing and plant population in *S. hamata.* The highest plant population (8866 plants ha^{-1}) was recorded in plots sown in May end followed by (6544 plants ha^{-1}) mid June, (2911 plants ha^{-1}) June end and lowest (1711 plants ha^{-1}) in the mid July.

In a two year study conducted at Jhansi, Anonymous (1987) noted that, plant population of *S.hamata* introduced in natural grassland showed decreasing trend with delay in sowing. Highest plant population (556333 plants ha^{-1}) in second year was recorded in the plots sown in May end followed by (360000 plants ha^{-1}) mid June, (314443 plants ha^{-1}) June end and the lowest (126667 plants ha^{-1}) in mid July sowing.

Anonymous (1992) reported from Jhansi that, *Stylosanthes* established in a native pasture at different times showed highest plant populaion (24073 plants ha^{-1}) in pre-monsoon sowing and the minium (6561 plants ha^{-1}) when sown after 15th July. Gardener (1993) indicated that, short lived herbacious are more efficient colonizers i.e. it produces more seedlings per unit area than *S. scabra* and *S. viscosa.*

2.1.2 Leaf area

Leaf area indicates the extent of surface available for photosynthesis by plant. Baldos and Javier (1979), while studying the importance of sowing time in Townsville stylo reported that, increase in leaf area was not entirely dependent on leaf numbers. However, photosynthetic area was attained from 28th to 56th day after sowing. Wilaipon et.al. (1979) tested the

effects of removal of apics, 60 per cent laminae and shoot supporting 60 per cent of laminae at various growth stages in *S. hamata* cv. verano reported that, maximum LAI was attained at 96^{th} day of plant growth. Luiz and Stanley (1989) also stated maximum leaf area at 95^{th} day in *S. hamata* and *S. guianensis* cv. Schofield.

2.1.3 Dry matter accumulation and growth rate

Studies conducted on *S. humilis* by Cameron (1967) showed that, plant growth was excellent when optimum day/night temperature was 30/25°C $\pm$ 3°C. He further reported that, night temperature below 25°C and day temperature below 30°C inhibited dry matter production. However, Skerman and Humphreys (1973) recorded maximum dry matter accumulation (23.32g $plant^{-1}$) in *S. humilis* at 31/17°C day/night temperature and reduced subsequently at lower temperature.

Fisher and Campbell (1977) stated that, stress during vegetative phase reduced plant growth in Townsville stylo (*S. humilis*). Growth rate was highest between 60 to 80 days and fell down to negative values as plant started senascence and approached to maturity. Similarly, Rai and Patil (1989 a) reported maximum growth rate in *S. hamata* upto 90 days of growth.

Wilaipon et.al. (1979) while studying the effects of removal of shoot apices and Laminae at various growth stages in *S. hamata* cv. Verano, observed linear increase in dry matter accumulation (1333.9 g m^{-2}) upto 132 days after sowing and reduced subsequently. The highest growth rate for dry matter accumulation was noticed between 75 to 85 days. They further stated progressive decrease in leaf dry weight index (-0.16) between 96 to 132 days.

Brolmann (1984 a) reported that, dry matter yield varied from 6.4 to 97.0 g plant $^{-1}$ from first cutting and 9.1 to 145.9 g plant $^{-1}$ from second cutting, amongst 111 ecotypes tested. In another study he (1984 b) tested the performance of various accessions of *Stylosanthes* in bahia grass and reported that, dry matter accumulation in *Stylosanthes* varied from 6 to 140 g plant $^{-1}$ year $^{-1}$. The dry matter accumulation in *S. hamata* was obseved more than 75 g plant $^{-1}$ year $^{-1}$. Reduction in dry matter due to water stress was reported by Luiz and Stanley (1989) in *S. hamata* and *S. guianensis*, while studied under pot culture.

At Fort Pierce Florida, during 1988 and 1989 Brolmann and Boman (1991) studied the performance of twenty two *Stylosanthes* accessions at five harvest dates reported that, dry matter production per plant across all dates ranged from 24.6 to 48.0 g in 1988 and 14.5 to 47.8 g in 1989. Reduction in dry matter yield during second year was attributed to slower growth.

2.1.4 Flowering

Cameron (1967) while studying flowering in *S. hamata* indicated that, length of period from sowing to flowering was reduced due to late sowing and plants flowered quickly in the inductive short days.

Ive and Fisher (1974) studied the flowering behaviour in *S. humilis* selections collected from 12 naturalized population in Queensland Northern Territory and Katherine ecotypes for three years and observed that, flowering of all lines hastened due to drought. From Queensland, Skerman and Humphreys (1975) also reported that, number of days to flowering and node number reduced in the late summer in *S. humilis* sown at 14 days

interval from 26th December 1971 to 19th April 1972. Studies undertaken on *S. guianensis* in control environment, Bryant and Humphreys (1976) reported that, duration of period of floral initiation to flower appearance was negatively associated with daily maximum temperature.

Fisher and Campbell (1977) concluded that, stress during vegetative phase hastened flowering by two weeks in *S. humilis.*

Baldos and Javier (1979) stated that, flowering in Townsville stylo reached to maximum in November and then decline in December.

Wilaipon et.al. (1979) reported flower appearance in *S. hamata* cv. Verano after 57 DAS. However, in another experiment they noted first flower appearance in 32 DAS. Similar findings were reported by Tudsri et al. (1989).

Ison and Humphreys (1983), while studying five selections of *S. guianensis* var-Guianensis, at different sites suggested that, cool temperature promoted increase in the photoperiod according to site.

Ison and Humphreys (1984) stated that, earliness in floral initiation under natural decreasing day length was negatively related to temperture regime over the range of 35/30 to 25/15^{0}C day/night temperature and warm temperature hastened flower initiation in *S. guianensis* cv. Endeavour. Trongkongsin and Humphreys (1988) reported similar findings in *S. guianensis* c.v. Endeavour.

2.1.5 Root and nodulation studies

Oke (1967) reported nodulation in *S. gracilis* three weeks after germination. Nodule growth was slow upto six weeks, which was enhanced latteron. The increase in plant growth was found to be coincide

with the increase in nodule size.

Torssell et. al. (1968) studied stand morphology of *S. humilis* and reported that, growth rate was highest upto 120 days and during main period of growth 80 per cent of the root length and 70 per cent of root surface area was in the top 30 cm soil. The density of root length varied very little below thirty cm.

Studies conducted on *S. humilis* (HBK), Baldos and Javier (1979) found maximum nodulation within four months time. However, Rai (1989 b) reported that, nodule number in *S. guianensis, S. hamata, S. humilis, S. scabra* and *S. viscosa,* were linearly increased upto 90 days (211.6 plant^{-1}) and then fell down to 164 at 120th day in most of the species.

Lopez et.al. (1984) observed maximum nodulation in wet season (June and Septemer) as compared to dry season in most of the tropical legumes including *Stylosanthes.*

2.1.6 Seed production and yield attributes

Cameron (1967), While studying the seed yield performance in *S. hamata* indicated that, seed yield was drastically reduced due to late sowing.

Skerman and Humphreys (1973) studied *S. humilis* under controlled environment and observed that, inflorescence density plant^{-1} (374.6) was highest at 110th day (31/31^{0}C, day/night temperature). Howeer, inflorescence weight including seed (11.5 g plant^{-1}) and ripe seed weight per inflorescence was maximum (5.14 mg) at 31/30^{0}C as well as 31/10^{0}C but ripe seed per inflorescence (6.2) was highest at 31/24^{0}C day/night temperature. The inflorescence density was positively related to earliness in sowing and

the seed formation ceased at 12°C mean night and 9°C minimum night temperature (Skerman and Humphreys, 1975).

Mannetje and Bennekon (1974) reported highest seed yield in *S. humilis* from early sowing. Tomar and Dixit (1988) also observed highest seed yield from 30th June sown crop as against the late sowing.

Studies undertaken on ten selections of *S. humilis* at Colombia, Brazil and Austrilia by Schoonover and Humphreys (1974) revealed that, seed production was more or less similar at 31/24°C and 24/17°C day/ night temperature. Considerable differences amongst the selections in respect of inflorescence, floret number, seed per set floret (0.43 to 0.63), seed weight (3.8 to 6.0 mg) seed yield plant^{-1} (4.0 to 14.7 g plant^{-1}) were also observed.

Cameron et. al. (1977) studied eighteen lines of *S. humilis* differing in flowering time and growth habit and reported that, early flowering lines produced higher seed as compared to late flowering lines, but seed yield was reduced due to moisture stress. Fisher and Campbell (1977) also reported that, pod yield in *S. humilis* was reduced due to late flowering. Briones et. al. (1979) while studying *S. humilis* stated that, sweeping up of fallen pods was most economical (110 kg ha^{-1}) though the seed recovery was maximum (119 kg ha^{-1}) by hand picking as against topping of terminal shoots (60 kg ha^{-1}) and cutting of whole plant (88 kg ha^{-1}).

Wilaipon et. al. (1979) reported highest inflorescence density (14500 m^{-2}), at 132th day. The variation in florets per inflorescence and seed set per floret was noticed from 8.8 to 11.5 and 1.85 to 1.95 respectively. In second experiment they observed maximum inflorescence density (8000 m^{-2}) having 5.7 to 6.9 florets per inflorescence and 1.68 to

1.84 seeds per set floret at 108th day. The seed yields obtained from first and second experiment was 141 to 171 and 106 to 180 g m^{-2} respectively in *S.hamata* cv. Verano.

Moolsiri et. al. (1980) confirmed the benefits of early sowing for *S. hamata* cv. verano and reported highest seed yield from mid May sown crop (1140 kg ha^{-1}) as against 990, 930, 630 and 30 kg ha^{-1} from June, July, August and September sowing respectively.

Thompson and Medeiros et. al. (1981), while working on seed production in *S. scabra* cv. seca recorded 620 kg seed yield ha^{-1} after August from standing crop and sweeping up of fallen seed.

Argel and humphreys (1983) observed maximum seed production in *S. hamata* cv. verano at 31/24°C day/night temperature. They further stated that inflorescence differentiation, rate of florate blooming and seed set, was delayed by day/night temperature of 20/16°C.

Norton et·al. (1992) stated that the correct timing of header harvesting in *S. hamata* cv. Verano is critical as seed yield recorded in early June was more (483 kg ha^{-1}) and delay in harvesting resullted 67 per cent reduction in the yield.

2.1.7 Biomass production and seed quality

Experiment conducted at Lansdown Pasture Research Station in May and July 1968 to study the digestibility of *S. humilis* by Plane (1969) observed that, seed + pod containes 5.54% N, 0.36% P, 0.30% S and 0.88% Ca. While studying *S. scabra* cv. Seca, Kowithayekorn and Moolsiri (1980) reported low harvest index form early sown crop. Similar observations were noted by Moolsiri et- al. (1980) in the case of *S. hamata* cv. Verano.

In a field trial at Khon kaen Thailand during 1978, Pongskul et al. (1982) obtained highest dry matter yield (8.5 t ha^{-1}) in *S. hamata* cv. verano from 15th May sowing over 22nd June (4.91 t ha^{-1}) and 30th July (4.12 t ha^{-1}).

McIvor (1983), while testing seven accessions from six *Stylosanthes* species during one growing season on disturbed cultivation and cultivated seedbed, reported lower yield from late sown crop.

In a study initiated to find out the suitable sowing technique and time of sowing of *S. hamata in* natural *heterogogon* dominated grassland, highest dry matter (26.47 q ha^{-1}) was reported from May end sowing as against mid June, July end and mid July (26.2, 22.41 and 20.32 q ha^{-1} respectively) (Anonymous, 1986 and 1992).

Williams et al. (1995) reported an increase in dry matter yield of *S. guianensis* cv. Savana due to early sowing.

2.1.8 Residual soil fertility

Henzell (1968) stated that, average legume growth under mowing or intermittent grazing yielded 40-210 kg N $ha^{-1} yr^{-1}$ and good legume growth yielded 336 kg N $ha^{-1} yr^{-1}$.

Singh and Shah (1991) showed that, introduction of legumes in grassland increased pre and post sowing available soil nitrogen (425.6 and 251.0 kg ha^{-1}) over control treatment.

Under different ley farming systems involving *cenchrus ciliaris, S. hamata* and *Sorghum bicolor*(Anonymous, 1992) it was reported that soil containes 202 kg N, 4.27 kg P and 358.0 to 421.3 kg K ha^{-1} after harvest of the crop.

2.1.9 Economics of seed production and benefit-cost ratio

In a survey carried out of various stylo growing tracts of the country, Singh et. al. (1994) observed benefit-cost ratio, 0.41, 1.31, 0.66 and 0.82 at Jhansi, Dharwad, Kolar and Anantpur respectively. They further reported that the cost of seed production at Anantpur was less (Rs. 13.31 kg^{-1}), compared to Kolar (Rs. 16.31 kg^{-1}), Dharwad (26.0 kg^{-1}) and the highest at Jhansi.

2.2 Effect of P_2O_5 on growth rhythm

Phosphorus is one of the most important nutrient limiting plant growth and crop yields. Considerable amount of research have been done on the effects of phosphorus in *Stylosanthes* on different parts of the world.

2.2.1 Plant population/Establishment

In a trial conducted on red soil of pH 5.6 having very low levels of phosphorus (4 ppm) and fertilized with 0, 112, 224 or 448 kg P_2O_5 ha^{-1}, Olsen and Moe (1972) reported that, P_2O_5 accelerate the rate establishment in *S. gracilis, Desmodium intortum* and *Medicago sativa.*

Robertson and Humphreys (1978) investigated the effects of superphosphate in *Arundinaria ciliata* dominated grassland and sown with *S. humilis* cv. Lawson stated that the density of *S. humilis* was negatively related to application of double superphosphate.

Shaw (1978) reported that, molybdenized superphosphate applied at the rate of 0, 125 or 250 kg ha^{-1} annually plus 250 kg initially, improved best stand and establishment in *S. humilis* oversown in *H. contortus* dominated grassland.

Gibert and Shaw (1980) stated that, *S. humilis* cv. Paterson, *S. hamata* cv. Verano and *S. scabra* cv. Fitzory sown on duplex soil containing low levels of available phosphorus and applied with 0-5 kg P ha^{-1} in first year and 0, 5, 10, 20 and 40 kg P ha^{-1} in second year to the plots receiving 5 kg P ha^{-1} earlier, plant population was 26-28 m^{-2} in the first year and 82 and 3 m^{-2} (new seedling and perennials) in the second year.

Dance (1980) while studying superphosphate requirement of *S. humilis* cv. Townsville on light soil observed that, establishment was unaffected by absence or presence of superphosphate.

Thompson et. al. (1983) also stated that, phosphorus fertilizer did not affect establishment on red lands.

2.2.2 Growth

While studying P_2O_5 requirement of *S. guianensis* fertilized with 0, 30, 60, 90 and 120 kg P_2O_5 ha^{-1} , Rai and Patil (1983) reported that, phosphorus application did not influence plant hight. In another study conducted on *S. scabra* vog; over two years, plant height remain unaffected at same rate of P_2O_5 but was maximum during 1980 with application of 60 kg P_2O_5 ha^{-1} and during 1981 with application of 60 or 120 kg P_2O_5 ha^{-1} (Rai and Patil, 1984). Similar findings of non indluence of P_2O_5 at any level (0,30,60, 90, and 120 kg ha^{-1}) on plant height in *S. hamata* were also reported (Rai and Patil, 1986).

Singh (1985) studied the effects of P_2O_5 on growth and establishment in *S. hamata* cv. verano intercropped with guinea grass reported that, P_2O_5 had no effect on plant height but number of branches plant $^{-1}$

increased significantly due to its application. Plant population was also increased by 28.5 per cent with 26.4 kg P_2O_5 ha^{-1} over control. Khara et. al. (1990) also stated significant increase in primary branches and dry matter production due to P_2O_5 in *S. hamata* cv. Verano.

Mohamad Saleem and Von Kaufmann (1986) investigated the effects of phosphorus application in *S. guianensis* cv. Cook, *S. guianensis* cv. Schofield and *S. hamata* cv. Verano and reported that, application of P_2O_5 at the rate of 0, 40, 80, and 120 kg ha^{-1} in first year and no further addition in the second year, had no effect on plant population but was increased from 250 plants m^{-2} in the first year to 500 plants m^{-2} in the second year.

Strickland and Greenfield (1988) studied adaptation of 52 legumes including *Stylosanthes* and 77 grass accessions to red earth soil at six sites in Southern Queensland reported that, phosphorus had no effect on establishment, persistence and spread.

Cadish et al. (1989) reported that, *Centrosema acutifolium, centrosema macrocarpum, zornia glabra, pueraria phaseoloides, Desmodium Ovalifolium, S. macrocephata, S. guianensis and S. capitata,* applied with Ca, S, Mg, Zn, Cu, B and Mo with or without 80 Kg P_2O_5 + 70 kg K ha^{-1} at the start of rainy season, legume density was 5 to 6 plants m^{-2}.

2.2.3 Root and nodulation in relation to P_2O_5 nutrition

Norman (1959) observed an increase in nodulation by 293% with application of superphosphate at the rate of 370 kg ha^{-1} over control.

Fisher (1970 a) studied the effects of superphosphate at the rate of, 0, 112, 224 and 448 lb $acre^{-1}$ on growth and development of

S. humilis reported that, application of superphosphate encouraged exploitation of soil by plant roots but P deficient swards were more resistant to drought.

Gates (1970) stated that, phosphorus stimulated nodulation in *S. humilis* even upto 250 kg P_2O_5 ha^{-1} and also increased P contents in the nodules. Nodules number, volume and dry weight was also increased by P_2O_5 application (Gates, 1974; Gates and Wilson, 1974).

Olsen and Moe (1972) indicated that, nodulation in *S. guianensis* and *Medicago sativa* was accelerated by phosphorus application. Singh and Singh (1980) indicated that, P_2O_5 application at the rate of 0-160 kg ha^{-1} increased nodule mumber, dry weight and percentage of effective nodules in *S. humilis.* Savastano et.al. (1985) also observed an increase in nodulation with application of P in *S. guianensis* cv. Schofield, Endeavour cook, *S. humilis* and *S. hamata.*

Mohamad Saleem and Von Kaufmann (1986) stated that, application of phosphorus at the rate of 0, 40, 80, 120 kg P_2O_5 ha^{-1} increased nodulation with increasing levels of applied P_2O_5 in *S. guianensis* cv. Schofield and cv. Cook. However, nodulation in *S. hamata* cv. Verano remain unaffected.

Gilbert et.al. (1989 a) stated that, root weight in *S. viscosa* CPI 34904 increased due to P application.

Mariyappan et.al. (1987) abserved maximum nodulation and nodule weight upto application of 120 kg P_2O_5 ha^{-1} in *S. gracilis.*

Luiz et.al. (1989) studied *S. hamata* and *S. humilis* in pot culture under glass house condition applied with Ca $(H_2PO_4H_2O$ - 163 mg; KCL - 80 mg; $MgSO_4$ - $7H_2)$ - 308 mg; H_3BO_3 - 0.50 mg; $CuSO_45H_2O$

- 2 mg; MoO_3 - 0.6 mg; $ZnSO_47H_2O$ - 2 mg and $MnSO_4H_2O$ - 4 mg and reported, highest root dry matter at every harvest in control treatment as compared to stressed.

2.2.4 Flowering and maturity

Fisher (1970 a) observed that, flowering in P deficient plants in *S. humilis* was delayed by one week. Robinson and Jones (1972) also reported delay in flowering by 2-3 weeks in P deficient plants of *S. humilis*.

Gilbert et·al. (1989 a) studied *S. guianensis* cv. Schofield, *S. scabra* cv. Seca and *S. viscosa* CPI 34904 on a low acid exctractable P and applied with either 0 or 50 kg P ha^{-1} to test their ability to grow in field condition and reported that, P application did not increase the length of growing season, but hastened flowering.

2.2.5 Yield attributes, production potential and quality traits

Gates et·al. (1966) indicated that, phosphorus application enhances protein levels in Townsville lucerne (*S. humilis* HBK)

Shelton and Humphreys (1971) reported in a study conducted on *S. humilis* that, inflorescence density was positively related to application of phosphorus. They observed that, application of 50 kg P ha^{-1} increased seed yield by 20 per cent, which was linearly related to logarithum of density upto 250 plants m^{-2} and stable over the upper density range.

Burt et·al. (1973) studied two Townsville stylo population collected from Townsville and Greenvale, fertiltzed with 377 kg molybdenized superphosphate in first year and 120 kg in the second year, reported seed yield variation from 2.8 to 3.5 g $plant^{-1}$. The test weight was also ranged from 2.25 to 2.56 g within the groups.

Rai and Kanodia (1980) tested the response of nitrogen and phosphorus on seed production in *S. humilis* and reported that, seed yield was increased by 34.7, 39.3 and 44 per cent with application of 20, 40 and 60 kg P_2O_5 ha-1 over control. Similar findings were reported in *S. guianensis* (Rai and Kanodia, 1982).

Rai and Kanodia (1982) tested the effects of phosphorus on seed germination (Lab. test) in *S. guianensis* (Abul) sw. and reported maximum germination (58.65) due to application of 60 kg P_2O_5 ha^{-1} and minimum in the control treatment. Austin et al. (1969) and Heydecker (1974) also reported similar findings.

Singh (1984) stated that, P application had no effect on crude protein contents in *S. hamata* intercropped with *Panicum maximum*. Mohamad Saleem and Von Kaufmann (1986) observed that, seed production in *S. quianensis* cv. Cook, cv. Schofield and *S. hamata* cv. Verano was significantly increased by phosphorus application. They further reported that, CP contents were raised by 1,5 and 3% in Cook, Schofield and Verano respectively with 40, 80 and 120 kg P_2O_5 ha^{-1} over control.

Mariyappan et al. (1987) studied the nutritional requirement of *S. gracilis* and reported that, protein yield was increased with increasing levels of P_2O_5 upto 80 or 120 kg ha^{-1}.

Kanodia et al. (1985), while studying the response of different levels of phosphorus on seed procution of *S. humilis, S. scabra* EC 40289 and EC 40205, *S. hamata, S. viscosa* and *S. guianensis* reported that, seed yield was signifacantly highest with P_2O_5 application at the rate of 40 kg ha^{-1} over control. However there were no significant

differences between 40 and 80 kg application. On the contarary yield was reduced at 80 kg level.

Winter and Chapman (1988) indicated that, *S. hamata* cv. Verano showed marked response to P_2O_5 on red earth, sandy red earth and euchrozen, to 40, 70 and 120 kg ha^{-1} for 90% maximum yield.

Studies conducted on *S. scabra* cv. Seca, *S. guianensis* cv. Schofield and *S. viscosa* CPI 34904 to test their ability to grow under P deficient condition by Gilbert et.al. (1989 a) reported that, seed yield was increased in seca only.

Khara et.al. (1990) reported that, number of florets inflorescence^{-1}, seed florets^{-1}, seed yield ha^{-1} and test weight in *S. hamata* cv. verano was significantly increased with application of phosphorus at the rate of 17.5 kg ha^{-1} over control. However phosphorus had no effect on inflorescence density.

2.2.6 Impact of P_2O_5 on dry matter production

Fisher (1970 b) investigated superphosphate requirement of *S. humilis* and reported that dry matter yield increased with its application and 75, 90 and 100% of the maximum yield could be obtained with 250, 375 and 625 kg superphosphate ha^{-1} respectively. However, Fisher and Campbell (1972) reported that, dry matter yield in *S. humilis* was significantly increased by application of superphosphate @ 750 kg ha^{-1}. Robinson and Jones (1972) also stated considerable increase in dry matter yield at higher rate of P_2O_5 applied at 0, 125, 375 or 1125 (9.6%P) kg ha^{-1} to *S. humilis*. McLeod (1974) observed an increase in the dry matter yield of *S. humilis* and Bermuda grass mixture upto 125 kg P_2O_5 ha^{-1} but 250 kg P_2O_5 could

not increase the yield further. While Moody and Edwards (1978) found under glass house condition that, P_2O_5 application at the rate of 100 kg ha^{-1} is sufficient to increase the dry matter production in *S. humilis* cv. paterson. Similar findings were reported by Gutteridge (1981) in *S. humilis* and *S. hamata.* Shelton et. al. (1981) also stated that, dry matter production in *S. humilis* was significantly increased with P and S aplication at the rate of 18, 54, 162 kg P_2O_5; 0 and 100 kg K_2O and 0-50 kg S ha^{-1}. Whereas Keerati-Kosikorn et al. (1987) reported that 0 or 50 kg S or 50 kg each of S + P_2O_5 increased dry matter yield in *S. humilis* and *S. hamata* in second year only.

Olsen and Moe (1972) studied *S. gracilis* on red soil having pH 5.6, with very low levels of P (4 ppm) and applied with 0, 112, 224 or 448 kg P_2O_5 ha^{-1} reported that, dry matter production was significantly increased with application of 112 kgP_2O_5 ha^{-1}.

Jones (1974) investigated the effects of P_2O_5 at the rate of 0, 24, 48, 96 and 192 kg ha^{-1} in. *S. guianensis, S. hamata, S. humilis S. scabra, S. viscosa, S. fruticosa* and *S. subserica* and stated that, dry matter production increased in all species upto 96 kg P_2O_5 ha^{-1} only, while higher dose at the rate of 192 kg ha^{-1} reduced the yield.

Bruce and Teitzel (1978) reported maximum dry matter in *S.guianensis* upto 50 kg ha^{-1} of P_2O_5 only. They concluded that, higher dose at the rate of 100 and 200 kg reduced the yield. Prasad (1981) indicated that, dry matter yield of *S. guianensis* alone or in grass mixture increased, with increasing P_2O_5 rates from 0-80 kg ha^{-1}. In Pot culture culture study conducted on *S. guianensis,* Bingo and Dacayo (1982) revealed that, dry matter yield per pot increased from 12.3 g in control treatment to 73.7 g

at highest dose applied at the rate of 800 kg ha^{-1}. Rai and Patil (1983) stated that dry matter yield in *S. guianensis* increased by 7.6, 17.6, 12.2 and 26.3%; in *S. scabra* vog., by 12.1, 22.5, 11.1 and 32.8% during 1980 and 18.3, 26.5, 19.9 and 39.7% during 1981 (Rai and Patil, 1984); in *S. hamata* by 13.4, 17.3 18.4 and 29.9% (Rai and Patil, 1985); and in *S. viscosa* by 15.6, 22.1, 28.3 and 35.7% (Rai and Patil, 1986) with application of 30, 60, 90 and 120 P_2O_5 ha^{-1} over control. Mohamad Saleem and Von Kaufmann (1986) also observed maximum dry matter in *S. guianensis* cv. Cook and Schofield upto 80 kg P_2O_5 ha^{-1} but Verano remain unaffected upto this level and latter dose of 120 kg ha^{-1} reduced the yield.

Studies conducted on *S. humalis* cv. Paterson *S.hamata* cv. Verano and *S. scabra* cv. Fitzory, applied with 0 to 5 kg P ha^{-1} in first year and 0, 5, 10, 20 and 40 kg p in the second year to earlier plots, Gilbert and Shaw (1980) observed no visible response to applied P in the establishment year. The dry matter yield of verano and fitzory was increased only in the second year.

Hewitt (1981) studied two sources of rock phosphate and five levels of phosphorus at two locations and reported that, dry matter yield in *S. hamata* increased at all levels of phospohorus (0, 5, 10, 20, 40 kg ha-1) from both sources of rock phosphate. Similar findings were reported by Impithuksa and Rungrattna Kasin (1989) in pot Culture.

Gill and Patil (1985) stated that, dry matter yield in *S. hamata* cv. Verano was increased from 56 q ha^{-1} to 96q ha^{-1} during first and second year respectively with application of 30 kg N and 50 kg P_2O_5 ha^{-1}.

Trial conducted on *S. hamata* cv. Verano intercropped with guinea grass, Singh (1985) reported that dry matter yield of *S. hamata* increased by 20.5 and 48.8 per cent with application of 13.2 and 26.4 kg P_2O_5 ha^{-1} respectively over control treatment.

Gilbert et. al. (1992) in glass house study indicated that, on red earth, *S. scabra* cv. Seca and Fitzory produced maximum yield with 20 kg P_2O_5 ha^{-1}. While *S. hamata* cv. Verano and CPI 33205 responded to highest application.

2.2.7 Chemical composition and nutrient yield

Jones (1968), tested yield response of superphosphate on Townsville lucerne (*S. humilis)* - grass pasture for three years and stated that, P had good residual effect to initial dressing of 336 lb ha^{-1} but did not responds to maintenance dressings applied in IInd and IIIrd year. Further he indicated that, P yield was increased but N content had little effect.

Fisher (1970 a) studied the effect of phosphorus on nutrient contents and P recovery in *S. humilis*, reported that, N and P contents in plants were not affected by application of superphosphate at the rate of 112, 224 and 448 lb $acre^{-1}$, however P recovery was maximum (20, 14 and 14%) at these levels. Falade (1973) stated an increase in P contents of various tropical legumes including *Stylosanthes* with P application.

Winter and Gillman (1976) tested the response of *S. guianensis/Brachiara decumbens* pasture to P on yellow soil in North Cape York Peninsula for three years with establishment rate of 0-130 P kg ha^{-1} followed by various combinations of 0 or 20 kg P ha^{-1} for next two years and reported that , P yield increased in the third year when P was fully applied. (In third

year P yield data showed that the values of applied P declined by about 70% each year).

Tudsri and Whiteman (1977) stated that, P content in the plant tops is closely related to P application.

Eng et. al. (1978) studied changes in yield, botanical composition, species frequency and chemical compostion in guinea grass-legume pasture (*Centro, Puero* and *S. guianesis*), fertilized with 20, 40 and 80 kg P ha^{-1} as rock phosphate and 20 kg P ha^{-1} as triple superphosphate, reported significant increase in P concentration in all species. They further indicated that, concentration of P during second year was increased than the first.

Shaw and Andrew (1979) concluded that, *S. guianensis* sampled at early flowering, fertilizer response would be expected if phosphorus content in the whole plant tops is below 0.14%, whilest responses are unlikely when these values are about 0.17 per cent.

Gilbert and Shaw (1980) investigated the effects of superphosphate applied at 0-5 kg P ha^{-1}in first year, and 0, 5, 10, 20, and 40 kg P ha^{-1} in the second year to earlier fertilized plots of *S. humilis* cv. Paterson, *S. hamata* cv. Varano and *S. scabra* cv. Fitzory reported that, phosphorus contents were slightly increased but nitrogen content remained constant with increasing phosphorus fertilizer. Bingo and Dacayo (1982), while studying *S. guianensis* at different P_2O_5 rates stated that, P uptake was increased with increasing P_2O_5 rates. Significant increase in N and P concentration was not reported by Hall (1982) in *S. humilis* and *S. hamata* fertilized with 10-20 kg S alone or with 19.2 kg P ha^{-1} or 1.6 kg S + 19.2

kg P ha^{-1} even though response to applied S and P was observed after five years. These findings were confirmed by Gilbert et. al. (1992).

While studiying superphosphate requirement in *S. humilis,* Dance (1985) indicated that, whole plant P at maturity varies from 0.06 to 0.10 per cent.

Mohamad Saleem and Von Kaufmann (1986) also reported an increase in P_2O_5 content due to application of P_2O_5 in *S. guianensis* cv. Cook, *S. guianensis* cv. Schofield and *S. hamata* over sown in natural perennial grass pasture fertilized with 100 kg P_2O_5 ha^{-1} at the time of establishment and 25 kg ha^{-1} given annually.

Gilbert et. al. (1989 b) stated that N concentration had slight effect but P concentration in plant and yield of N and P in Seca, Schofield and CPI 34904 were increased with application of 0-50 kg P ha^{-1}. However P had no effect on K concentration in plant (Gilbert et. al. 1989 c).

Smith et. al. (1990) concluded that, for maximum P uptake *S. hamata* should always be grown on P deficient soil.

Hendrickson et. al. (1992) investigated the effects of superphosphate on micro and macro nutrient concentrations in grazed stylo native pasture and found that, application of superphosphate increased P content from 0.11 to 0.15 per cent in legume but decreased N/S ratio from 28 to 22.

2.2.7 Soil enrichment through P_2O_5 fertilization

Shaw (1978) studied changes in the yield and botanical composition of native pasture oversown with *S. humilis* and fertilized with 0, 125 or 250 kg molybdenized superphosphate plus an extra 250 kg ha^{-1}

iniitially reported that, P_2O_5 in soil was greatly increased by P_2O_5 application.

Mohamad Saleem and Von Kaufmann (1986) did not observe noticeable increase in organic carbon due to P_2O_5 application from 0 to 80 kg in *S. hamata* cv. Verano. However, in *S. guianensis* cv. Cook available P ppm in soil was increased due to 120 kg P_2O_5 ha^{-1}.

2.2.8 Net return

Rai and Kanodia (1980), while testing the response of four levels of phosphorus and two levels of nitrogen in *S. humilis* reported that, fertilizer either alone or in combination resulted in additional profit over control. Highest profit or Rs. 7041.45 was obtained with application of 20 kg N + 60 kg P_2O_5 ha^{-1}.

2.3 Response of potash in relation to plant growth and nodulation

Potassium is a monovalent cation and is taken up with a great ease by high CEC legume roots. It plays an essential part in the formation of starch, and production as well as translocation of sugar.

Gates and Wilson (1974) indicated that, *S. humilis* grown in pot, N deficient light texture solodic soil and fertilized with 0, 187.5 and 375 kg KCl ha^{-1}, response to K_2O on nodulation was minor.

Rai and Patil (1983) investigated the effects of K_2O application at the rate of 0 and 30 kg ha^{-1} on *S. guianensis* stated that, plant height and dry matter production remain unaffected due to potash. Similar observations were noted in respect of *S. scabra* vog. by Rai and Patil (1984) and subsequently in *S. hamata* (Rai and Patil, 1985).

Studies conducted on 52 legumes including *S. hamata* and 77 grasses on red soils at six sites in Southern Queensland, Strickland

and Greenfield (1986) showed that, K_2O had no effect on establishement, presistence or spread of legumes and grass accessions.

Balbir Singh (1994), while studying intercropping of *S. hamata* in *Chrysopogon fulvus* stated that, 0 or 40 kg K_2O ha^{-1} had no variable effect on plant height, primary and secondary branches in *S. hamata.*

2.3.1 Production potential and quality under potash fertilization

Wendt (1971) stated that, pure stand of *Hyparrhenia rufa, P. maximum, S. guianensis, C. pubescens* and *M. atropurpureum* given 0, 44.8 or 89.7 kg K_2O ha^{-1} in the first harvest year, there was no response to applied potash. Eyles et. al. (1974) however, indicated slight increase in dry matter yield in pasture legumes due to potassium.

Bruce and Teitzel (1978) investigated the nutritional requirement of *S. guianensis* (cv. Schofield and Endeavour) reported that, higher doses of potash at the rate of 100 and 200 kg ha^{-1} resulted into reduction in the yield.

Javier and Marasigam (1978) stated that *S. quianensis* cv. Schofield and *S. humilis* cv. Townsville stylo oversown in *Calopogonium mucunoides* and *Desmodium* species, fertilized with 0 to 100 kg K_2O ha^{-1}, dry matter yield was significantly increased with application of potash over control. However, while studying the effects of 100 kg N, 150 kg P and 100 kg K_2O ha^{-1} on the yield of *S. guianensis* cv. Schofield, Javier et. al. (1979) reported no response to applied potash.

Shelton et. al. (1981) studied *S. humilis* on red latsol indicated that, application of poash at the rate of 0 to 100 kg ha^{-1} had no effect on seed yield. Wickham et. al. (1977) also reported similar findings.

Gutteridge (1982) observed in pot culture (various.upland soils of N.E. Thailand) that, application of 25-400 kg K_2O ha^{-1} as KCl or K_2SO_4 increased dry matter yield in *S. humilis* cv. Townsville on upland soils of North Thailand. He further reported that KCl had no deleterious effects but response to potash was only apparent in the second year. However, K_2SO_4 increased the yield in all soils.

Rai and Patil (1983) reported that, potassium had no significant influence on dry matter yield and CP content in *S. guianensis*. Similar findings on dry matter yield during 1980 and 1981 were reported by Rai and Patil (1984) in *S. scabra* vog. The dry matter yield and CP content in *S. hamata* were also not affected with application of potash (Rai and Patil, 1985). However, there was slight increase in the dry matter yield due to potassium in *Stylosanthes viscosa* sw. (Rai and Patil, 1986). In all the above studies they reported that potash had no effect on crude portein contents of *S. scabra* vog., *S. hamata* and *S. viscosa* sw. (Rai and Patil, 1984, 1985, 1986).

In a two year study on sandy clay loam, Singh (1984) stated that, application of potash had no effect on crude protein content in *S. hamata* cv. Verano intercropped with green panic.

Studied conducted on *S. capitata,* Roa (1989) concluded that, 22 kg P + 40 kg K + 20 kg Mg + 12 S ha^{-1} found to be the optimum dose for seed production.

Standley et. al. (1990) indicated minor response to potash application in *S. hamata* cv. Verano.

2.3.2 Nutrient concentration

Brolmann and Sonoda (1975) studied the effects of potassium on nutrient concentration in *S. guianensis* reported that, K content in plants were lowest and showed the symptoms of potash deficiency when ferlilized with 19 or 38 kg K_2O (0.61 and 0.69 per cent respectively). However, K contents were increased from 0.81 to 1.03 per cent when fertilized with 95 kg K_2O ha^{-1}.

Studies conducted on *S. humilis,* Shaw and Andrew (1979) stated that, fertilizer response could be expected if potassium concentration in the plant tops is below 0.4%.

Coelho and Blue (1980) tested the response of *S. guianensis, S. viscosa, S. fruticosa, S. hamata* and *S. scabra* to applied K as KCl at the rate of 0, 20, 40, or 60 ppm based on 2 kg soil per pot stated that, K contents increased with increasing rates of applied K.

Monteiro et. al. (1982) studied the effects of 100 kg K_2O ha^{-1} on guinea grass fertilized with 0, 75, 150 or 225 kg N ha^{-1} and guinea grass mixed with *S. guianensis* on red yellow podsol low in available k stated that, K concentration did not increase significantly without K in grass as well as legume.

Werner (1982) reported that, without K, herbage K concentration was low in *S. guianensis* and *S. hamata* cv. Verano.

Sanzonowicz and Vargas (1984) stated that, K content and total uptake of N, P, K in plant increased due to application of potash.

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

The details of the materials used and the methods adopted during the course of investigaiton are described below :

3.1 Experimental site and soil characteristics

A field experiment was carried out for two consecutive years during Kharif (rainy) season of 1994-95 and 1995-96 at Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi (U.P.). The soil of the experimental field represented Parwa group of Bundelkhand region. As per soil taxonomy, the soil is covered under the order Entisol, medium in water holding capacity and prone to crust formation after the rains. Soil fails to support the plant growth if drought extends for 2-3 weeks even under mild evaporative demand.

A composite soil sample to a depth of 0-30 cm was collected from the experimental field, in first and second year, respectively from randomly selected spots. The samples were air dried, ground and sieved through 2 mm sieve to determine important physio-chemical properties. The methods adopted and the results of the analysis are presented in Table 1.

Data presented in Table 1 indicated that the soil under experimentation was sandy loam in texture with a pH of 6.6 having neutral in reaction. It was low in available nitrogen and phosphorus and medium

Table 1 : Mechanical and chemical composition of soil of the experimental field.

Soil characteristics	values 1994-95	values 1995-96	Method and References
(a) Mechanical composition			
Sand (%) (Coarse + fine)	52.45	—	Standard International pipette Method (Piper. 1966)
Silt (%)	28.00	—	
Clay (%)	19.55		
Textural class	Sandy loam		
(b) Physico-chemical properties			
Bulk density (g cm^{-3})	1.36	1.33	Core sampler (Piper, 1950)
Chemical Analysis			
Organic carbon (%)	0.376	0.418	Walkey and Black's rapid titration method (Jackson, 1967)
Total Nitrogen (%)	0.336	0.390	Modified Kjeldahl's method (Piper. 1966)
Total P (%)	0.016	0.042	Vanado-Molybdate-phos - phoric-yellow colour method (Jackson, 1967)
Total K (%)	0.758	0.877	Flame Emission Spetro Photometer method (Jackson, 1967)
Available Nitrogen (kg ha^{-1})	209.52	229.14	Alkaline $KMnO_4$ method (Subbiah and Asija. 1956)
Avalaible Phosphorus (kg ha^{-1})	10.33	13.81	Olsen's method (Olesen et. al., 1954)
Available Potassium (kg ha^{-1})	241.83	281.21	Flame Emmision Spectro Photometer (Jackson, 1967)
Electrical Conductivity (dsm^{-1} at 25^{0}C)	0.103	0.099	Sloubridge method (Jackson, 1967)
Cation exchange capacity (mole $(p)^{+}$ kg^{-1})	9.35	12.34	Flame Emission Spectro Photometer (Richards, 1954)
pH	6.6	6.6	Glass electrode method (Piper, 1966)

high in available potassium during 1994-95. In 1995-96 the content of available nitrogen was low but phosphorus and potassium were medium and high respectively.

3.2 Weather

Jhansi is situated at 25^0 27' North latitude and 78^0 35' East longitude, 271 meters above mean sea level in a semi-arid tract plateau and hill region of India. The rainfall ranges from 800-1100 mm with annual mean of about 958 mm. The potential evapotranspiration goes as high as 1400-1700 mm. resulting in moisture index value of -40 to -50. The rainfall is erratic in nature and more than 90% of the rainfall is received within 10 weeks from July to mid September with many intermittent long dry spells. The total rainfall is generally received in less than 50 rainy days. The winter rains are meagre and uncertain. The drought in the month of June and September is expected once in three years and during July and August once in seven years. Two consecutive years experiences drought in twelve years. Monsoon generally commences from the last week of June but sometimes is delayed upto the first week of July. The active monsoon generally withdraw by mid September. Sometimes light showers are received in the winter season. Light to moderate frost occasionally experienced in the month of December and January.

The average annual temperature is usually high and there is a vast variation between maximum and minimum temperatures. The highest temperature in May and June sometime goes upto 48^0C. Such high temperature coupled with windy days result in high potential evapo-transpiration. The details of weather conditions prevailing during the period of experimentation are

presented in Table 2 and 3 and depicted in Fig. 1 to 4.

The total rainfall during cropping period was 528.5 mm in 1994-95 and 837.10 mm during 1995-96, which was received in 37 and 49 rainy days in the respective years. In 1994-95 active monsoon was practically withdrawn from standard week 37 (September 10th). Contrary to this, during second year the cessation of monsoon started from standard week 40 onwards, though some intermittent showers were received during standard weeks 52, 1, and 3. The relative humidity during 1994-95 varied from 58 to 97 per cent for period I and from 21 to 83 per cent for period II. The corresponding values in 1995-96 ranged from 46 to 98 and 26 to 80. The maximum and minimum temperature ranged from 18.6°C to 41.9°C and 2.9°C to 32.5°C during 1994-95 and from 20.0°C to 45.1°C and 3.0°C to 30.7°C during 1995-96, respectively. The highest figure of maximum and minimum temperature were recorded in the standard weeks 25, 24 and 51, 49 during the two respective years. The mean weekly evaporation varied from 1.7 to 12.7 mm during 1994-95 and from 1.5 to 15.4 during 1995-96. The minimum values for evaporation were observed in the standard weeks 2 and 1 during 1994-95 and 1995-96, respectively. However, the maximum evaporation occured in the standard weeks 25 and 24 during both the years.

Table 2 : Weekly mean meteorological data during crop period 1994-95

Standard week number	Week starting from	Weekly cumulative rainfall (mm)	Number of rainy days	Relative humidity (%)		Temperature oC		Pan Evaporation (mm) day^{-1}
				Period I	Period II	Maximum	Minimum	
24	June 11	13.5	1	58	37	38.6	27.3	9.3
25	June 18	14.2	1	61	38	41.9	32.5	12.7
26	June 25	77.1	5	80	77	33.8	25.2	4.8
27	July 2	10.8	1	90	71	32.5	25.3	4.2
28	July 9	44.1	4	91	73	34.2	25.6	4.0
29	July 16	159.2	6	97	80	31.1	24.6	2.6
30	July 23	29.2	3	92	83	30.9	25.2	3.2
31	July 30	36.4	4	94	74	31.1	21.8	3.0
32	Aug. 6	81.4	5	96	79	31.0	24.4	2.8
33	Aug.13	5.0	1	92	76	31.5	24.3	3.4
34	Aug.20	32.6	4	95	78	31.0	23.5	2.9
35	Aug.27	1.2	-	93	71	32.0	24.7	3.3
36	Sept.3	21.2	2	92	71	31.3	24.2	3.7
37	Sept. 10	-	-	91	62	33.0	23.2	4.4
38	Sept. 17	2.0	-	85	49	33.5	22.1	4.4
39	Sept.24	-	-	78	29	34.9	17.1	5.8
40	Oct. 1	-	-	85	29	34.9	16.3	5.3
41	Oct. 8	0.60	-	85	27	35.1	16.9	4.5
42	Oct.15	-	-	85	21	32.2	13.0	4.5
43	Oct. 22	-	-	85	27	33.0	14.6	4.4
44	Oct. 29	-	-	92	29	32.9	13.0	3.8
45	Nov. 5	-	-	94	27	30.4	11.6	3.3
46	Nov. 12	-	-	93	25	30.0	10.5	2.7
47	Nov. 19	-	-	95	31	26.8	8.5	2.6
48	Nov. 26	-	-	93	23	29.2	8.8	3.0
49	Dec. 3	-	-	94	23	28.8	9.1	2.8
50	Dec. 12	-	-	91	29	24.6	5.7	2.8
51	Dec. 17	-	-	95	33	23.1	2.9	2.0
52	Dec. 24	-	-	96	32	26.6	6.1	2.2
1	Jan. 1	-	-	96	53	22.5	4.3	2.1
2	Jan. 8	-	-	94	63	18.6	6.7	1.7
3	Jan. 15	-	-	97	49	19.7	4.7	1.8
Total rainfall during crop period		528.5	37					

Period I and II denotes relative humidity at 07.16 and 14.16 hours respectively

Table 3 : Weekly mean meteorological data during crop period 1995-96

Standard week number	Week starting from	Weekly cumulative rainfall (mm)	Number of rainy days	Relative humidity (%) Period I	Relative humidity (%) Period II	Temperature oC Maximum	Temperature oC Minimum	Pan Evaporation (mm) day^{-1}
24	June 11	8.0	1	57	26	45.1	30.7	15.4
25	June 18	35.6	3	73	54	37.7	23.9	8.9
26	June 25	17.0	1	76	42	37.8	26.5	9.1
27	July 2	-	-	46	26	41.1	27.2	13.8
28	July 9	48.2	3	85	59	37.2	25.9	7.1
29	July 16	76.9	5	95	75	31.6	25.3	4.1
30	July 23	83.9	3	96	72	32.1	23.9	5.1
31	July 30	151.2	4	95	74	31.5	24.5	4.1
32	Aug. 6	56.5	7	95	80	29.8	20.8	3.5
33	Aug.13	18.0	2	92	69	32.0	24.5	4.1
34	Aug.20	123.9	7	98	83	30.6	23.7	2.4
35	Aug.27	12.6	1	97	74	32.8	24.7	3.7
36	Sept.3	70.8	4	93	80	30.5	22.6	4.7
37	Sept. 10	74.6	3	96	61	32.5	22.6	3.6
38	Sept. 17	1.4	-	89	59	33.5	22.6	4.4
39	Sept.24	8.4	1	91	44	35.4	21.5	4.9
40	Oct. 1	-	-	85	32	36.9	19.7	5.1
41	Oct. 8	-	-	89	39	34.6	19.8	4.6
42	Oct.15	-	-	88	37	34.5	18.0	4.0
43	Oct. 22	-	-	89	25	32.6	12.8	3.9
44	Oct. 29	-	-	88	24	31.1	11.4	3.9
45	Nov. 5	-	-	85	33	30.3	13.1	3.7
46	Nov. 12	-	-	91	26	30.4	10.4	4.3
47	Nov. 19	-	-	78	27	27.6	8.3	3.1
48	Nov. 26	-	-	89	28	27.7	8.4	3.3
49	Dec. 3	-	-	91	24	24.2	5.1	2.9
50	Dec. 12	-	-	94	33	26.3	7.7	2.6
51	Dec. 17	-	-	94	37	26.1	9.0	2.6
52	Dec. 24	6.6	1	96	67	20.9	6.8	1.9
1	Jan. 1	26.1	1	97	69	20.5	8.6	1.5
2	Jan. 8	-	-	96	55	22.4	7.6	1.6
3	Jan. 15	17.4	2	96	62	20.0	8.5	1.9
Total rainfall during crop period		837.10	49					

Period I and II denotes relative humidity at 07.16 and 14.16 hours respectively

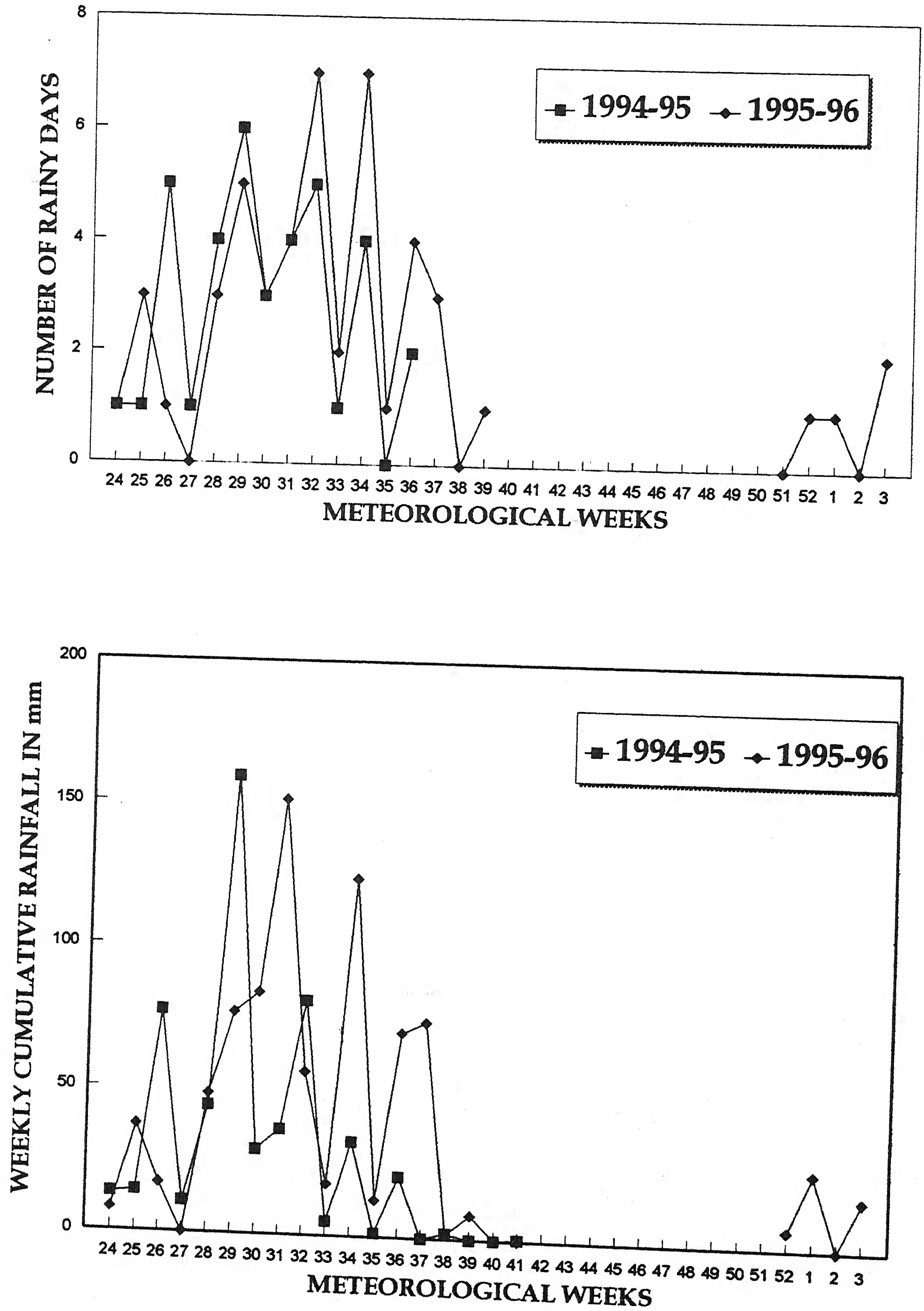


FIG. 1: METEOROLOGICAL DATA FOR KHARIF 1994-95 AND 1995-96

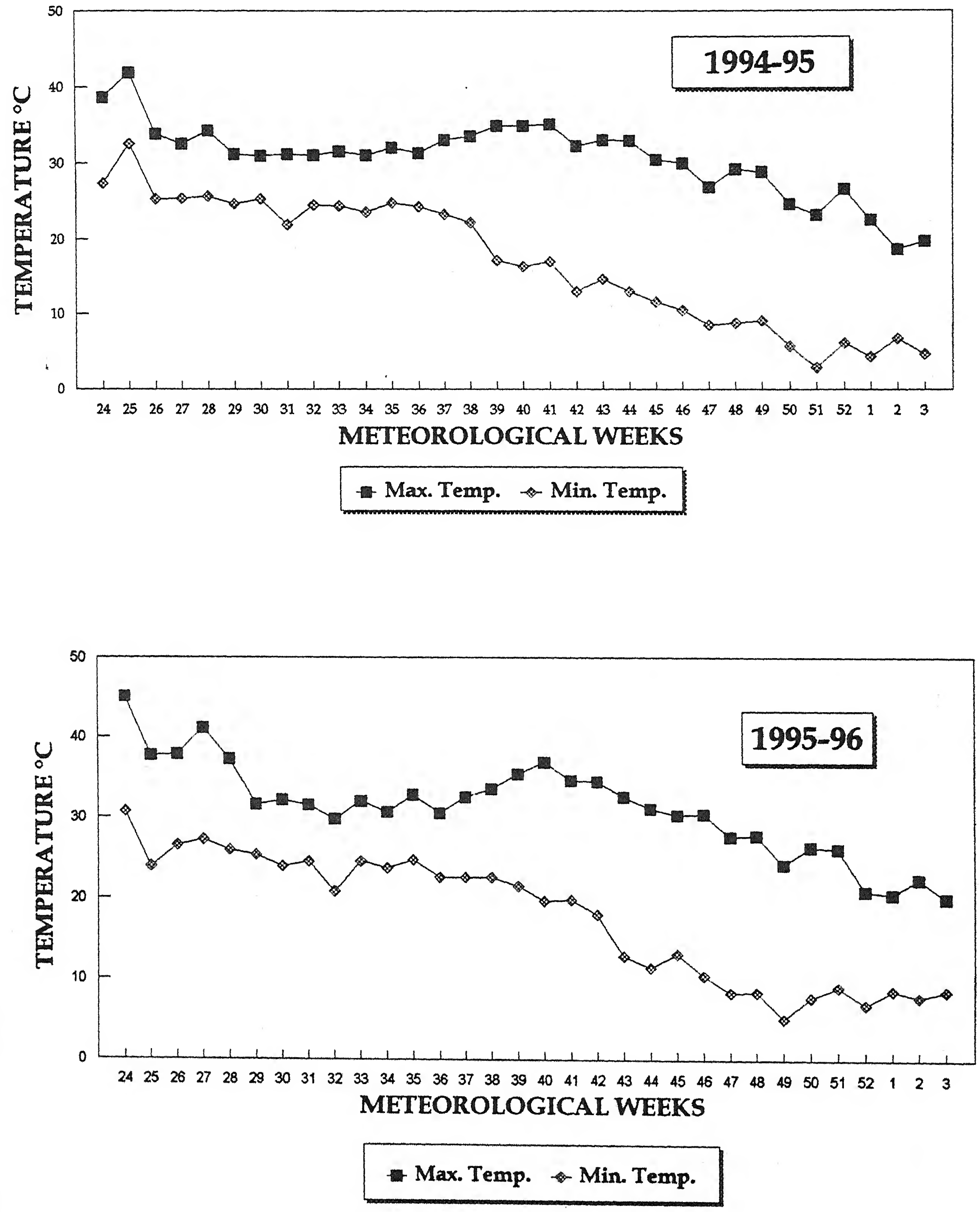


FIG.2: METEOROLOGICAL DATA FOR KHARIF 1994-95 AND 1995-96

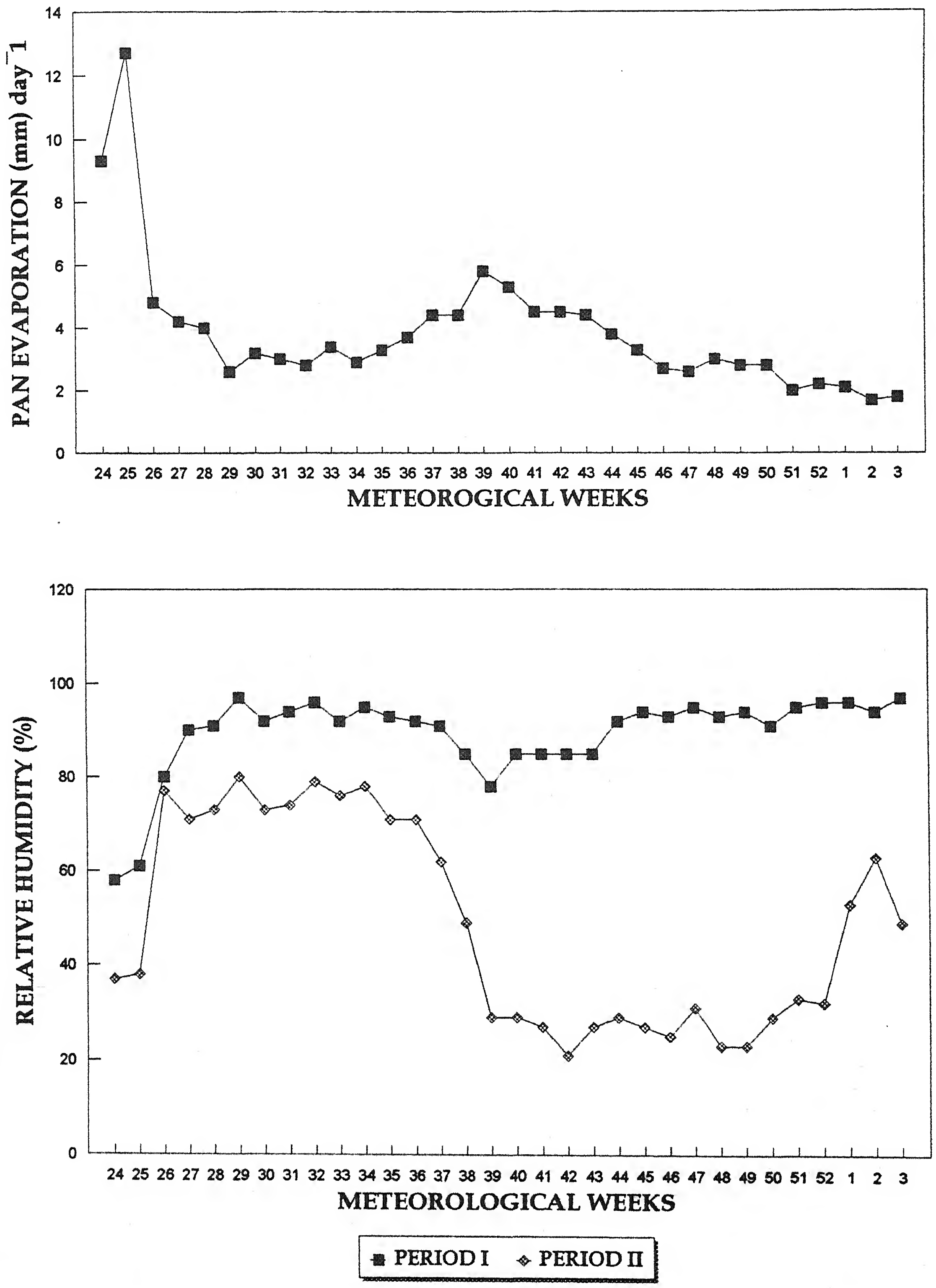


FIG.3: METEOROLOGICAL DATA FOR KHARIF 1994-1995

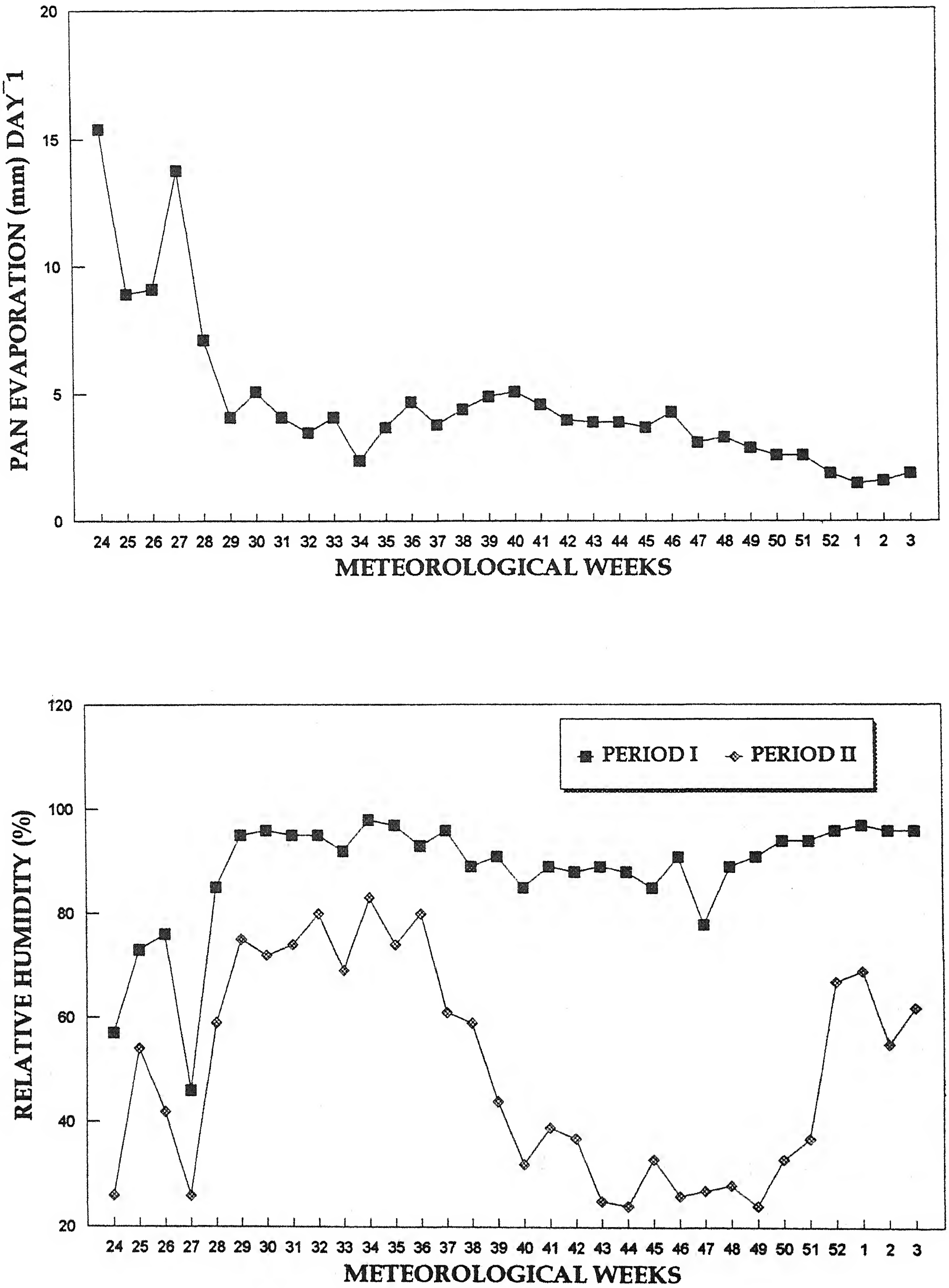


FIG.4: METEOROLOGICAL DATA FOR KHARIF 1995-1996

N

FIG. NO. 5 : **PLAN OF LAYOUT**

R I

D1

3.0m 3.0m 0.5m 1.0m

POK1	P2K3	P1K0	POK0
P3K1	P2K0	P2K2	P1K2
P1K1	P3K2	P1K3	POK3
P3K3	POK2	P3K0	P2K1

1.0m

D3

P2K0	P1K2	POK0	P1K0
P2K3	POK3	P1K1	P3K2
P3K3	P3K1	P3K0	POK2
POK1	P2K1	P1K3	P2K2

D2

P3K1	POK3	POK1	P2K2
P2K3	P2K0	P1K0	P3K3
P3K2	POK2	P2K1	P1K2
POK0	P1K1	P3K0	P1K1

D4

P2K1	POK2	P3K2	POK0
P1K3	P3K3	P2K3	P1K0
P2K2	P3K1	POK3	P1K2
POK1	P3K0	P1K1	P2K0

R II

D2

P3K1	P1K2	POK0	P2K1
P2K0	POK3	P3K2	POK1
P1K1	P3K0	P2K2	P3K3
P2K3	P1K3	POK2	P1K0

D4

POK1	P2K0	P2K1	P3K3
P2K3	P3K1	P3K2	POK2
POK0	P2K2	P1K3	P3K0
P1K0	P1K2	POK3	P1K1

D1

P1K3	P3K0	POK1	P1K2
POK1	P1K3	P3K3	POK0
P2K0	P2K2	P1K1	P2K1
P3K2	P1K0	P3K1	POK3

D3

P2K3	P3K2	P2K2	POK1
POK0	P2K0	P1K2	P3K1
P1K0	POK3	P3K3	P1K3
P1K2	P3K0	P2K1	P1K1

No. of replications = 4
Total No. of plots = 256

Gross plot size = 3.0 m x 3.0 m
Net plot size = 2.5 m x 2.5 m

(Layout not to scale)

PLAN OF LAYOUT

N

R III

D4

P0K0	P0K1	P1K1	P3K0
P2K2	P2K0	P2K3	P1K0
P3K1	P3K3	P1K3	P1K2
P0K2	P3K2	P2K2	P0K3

D1

P3K0	P0K2	P0K3	P3K1
P0K1	P2K1	P3K3	P0K0
P1K1	P1K2	P2K2	P1K3
P1K0	P2K0	P3K2	P2K3

D3

P1K0	P3K0	P1K2	P0K3
P2K3	P1K1	P2K2	P1K3
P0K1	P3K3	P2K0	P3K2
P0K0	P0K2	P3K1	P2K1

D2

P1K1	P3K2	P1K3	P3K1
P0K1	P0K2	P2K3	P1K2
P3K0	P2K1	P0K3	P0K0
P2K0	P1K0	P3K3	P2K2

R IV

D3

P1K2	P2K0	P1K0	P0K0
P0K3	P2K3	P3K3	P1K1
P3K1	P3K0	P0K2	P3K3
P2K2	P0K1	P2K1	P1K3

D2

P0K0	P0K3	P0K1	P3K1
P1K0	P2K0	P2K3	P3K3
P1K2	P0K2	P2K1	P3K2
P3K0	P0K0	P1K3	P1K1

D4

P0K1	P1K1	P2K0	P3K0
P3K1	P0K3	P1K2	P2K2
P1K0	P3K3	P2K3	P1K3
P2K1	P2K2	P0K1	P3K2

D1

P2K0	P3K1	P1K2	P2K2
P0K1	P1K0	P0K0	P2K3
P3K2	P1K3	P1K1	P3K0
P0K2	P3K3	P2K1	P0K3

3.0m 3.0m 0.5m 1.0m 1.0m

No. of replications = 4
Total No. of plots = 256

Gross plot size = 3.0 m x 3.0 m
Net plot size = 2.5 m x 2.5 m

(Layout not to scale)

3.5 Experimental details

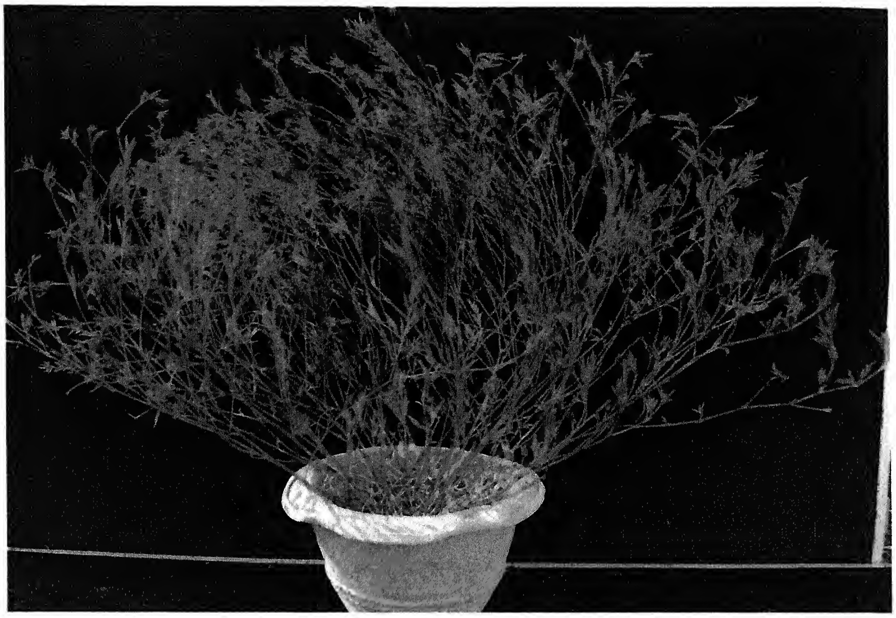
The site of the experiment was same for both the seasons. The details of the experiment and the symbols used are given below :

Treatments :

A. Main treatments	:	Sowing time :	4
		Last week of June	D1
		Mid July	D2
		Last week of July	D3
		Mid August	D4
B. Sub treatments	:	P_2O_5 Levels (kg ha^{-1}) :	4
		0	P0
		25	P1
		50	P2
		75	P3
	:	K_2O Levels (kg ha^{-1}) :	4
		0	K0
		60	K1
		120	K2
		180	K3

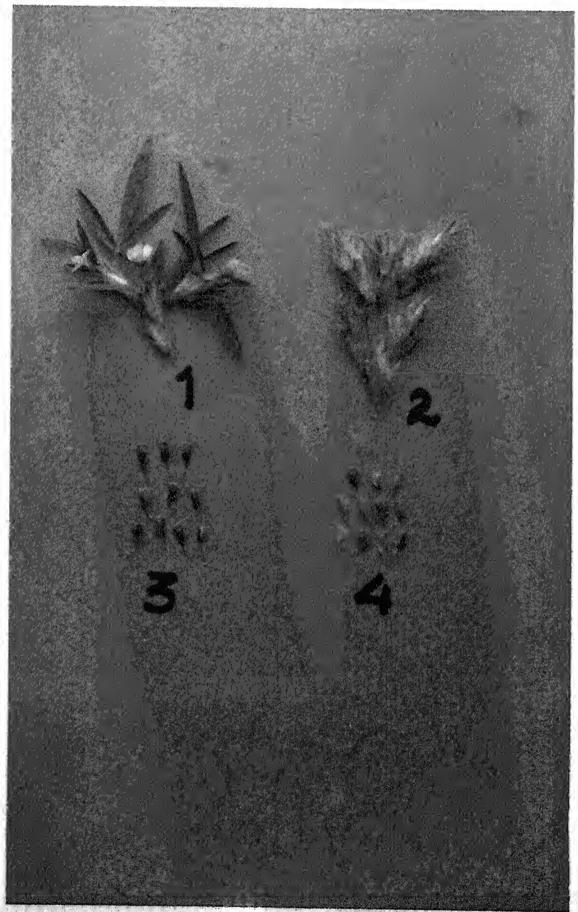
Total treatment combination	:	4x4x4=64
Experimental design	:	Split plot
Replications	:	Four
Total No. of plots	:	256

PLATE - 1



Stylosanthes hamata cv. Verano

PLATE - 2



i)	Flowers	iii)	Hooked seed
ii)	Balls	iv)	Seed without hook

Plot size	:	Gross	: 3.0m x 3.0 m = 9.0 m^{-2}
		Net	: 2.5 m x 2.5 m = 6.25 m^2
Spacing (row to row)	:	50 cm	
Sowing method	:	Line sowing	
Number of rows in Gross plot	:	6	
Number of rows in net plot	:	4	
Row orientation	:	North - South	

3.6 Plant characteristics

Stylosanthes hamata cv. Verano is a quantitative short day response type (Cameron and t'Mannetje, 1977), green in colour, herbaceous, procumbent and self-fertilized indeterminate plant of tetraploid line with 2n = 40. It has trifoliate leaves with individual leaflets long and slightly broader in the middle. Stem is errect and grows upto 90-100 cm with a diameter 3.2 to 5.0 mm and bearing 140-150 branches. The stem has a line of very fine short white hairs on one side only. It fowers in 65 to 75 days after sowing and produces seed pod (ball) consisting two seeds in each flowering spike. The upper seed has a reduced hook about 3 to 5 mm long. While the lower seed, which develops latter, is without hook. The Maturity period depends upon the climatic and edaphic conditions and varies from 110 to 170 days with a seed yield potential of 150 to 1500 kg ha^{-1}. It produces good amount of biomass about 50 to 60 quintal ha^{-1}. Protein levels are reasonable and *in vitro* digestibilities are in the order of 60 to 65 per cent. It has greater competitive ability, drought resistance and wide soil adaptibility (Plate 1 and 2)

3.7 Fertilizer schedule

A common starter dose of 20 kg N ha^{-1} through urea (46%) and phosphorus and potash as per treatments through single superphosphate (granular 16% P_2O_5) and muriate of potash (60% K_2O) respectively were applied to the soil before placing the seeds in the very shallow furrows during first year. However, during second year phosphorus and potash application (as per the treatments) were made after commencement of the monsoon rains.

3.8 Sowing

Seeds were sown at the rate of 6 kg ha^{-1} after giving hot water treatment and thereafter treating with thirum at the rate of 2 g kg^{-1} , in the furrows at 50 cm apart at various times as shown as under

Sowing time	Sowing date	Period
Last week of June	28th June	24 June - 30 June
Mid July	13th July	12 July - 18 July
Last week of July	27th July	24 July - 30 July
Mid August	13th August	12 August - 18 August

Seeds were covered with light layer of soil not more than one cm to have seed-soil-moisture contact for uniform germination. During second year no sowing was made as the crop was established by self seeding and regeneration from the old tissues.

3.9 Crop management

Hand weeding once after one month of sowing in all the treatments, and uprooting of taller weeds twice in 28th June and 13th July sown crop was done during first year. During second year, one weeding was carried out at seedling stage. Thinning and gapfilling was taken up wherever possible by uprooting and planting the seedlings from thick to thin places in the same plot. Excess water during heavy rains was drained out to avoid stagnation.

3.10 Biometric observations

Following observations on growth characters and yield attributes were recorded at different stages of crop growth and after harvest. Observations such as height of plant, stem diameter, number of branches, leaf area, leaf area index and dry matter accumulation plant^{-1} were recorded at seedling, 80% flowering and at harvest during both the years.

3.10.1 Pre-harvest studies

3.10.1.1 Plant population

The number of plants per meter row length were counted from three places in each plot after one month of sowing and prior to harvest in the first year. During second year plant population was recorded by placing the quadrat (25 x 25 cm) at three places in the same plot at seedling and prior to harvest. Mean was worked out to know the plant population m^{-2} and subsequently ha^{-1}.

3.10.1.2 Height of plant

Height was measured in centimeter by tape from ground level to the growing apex of the plant in fixed one meter row length (2 places)

in the first year and 25 x 25 cm square meter plot (2 places) during the second year. Average was worked out to know the height plant^{-1}.

3.10.1.3 Stem diameter plant $^{-1}$ (mm)

Stem diameter was measured at thickest portion of the plant by screw guage from the fixed one meter row length and 25 x 25 cm square plot (at 2 places) during first and second year respectively at various growth stages reffered above. Average was worked out to know the average stem diameter plant^{-1}.

3.10.1.4 Number of branches plant^{-1}

The total number of branches plant^{-1} were counted at different stages mentioned above from the fixed one meter row length and 25 x 25 cm square plot at 2 places each during first and second year respectively. The average was worked out by dividing the total number of branches with number of sampling plants.

3.10.1.5 Leaf area plant^{-1} (dm^2)

Leaf area indicates the extent of surface available for photosynthesis by plant. Fifty leaves from the plants, used for dry matter accumulation studies were plucked and leaf area was measured by leaf area meter (CID-CZ-251). Leaves were oven dried to a constant weight at 65^{0}C. Leaf area per plant was worked out and expressed in dm^2 on dry weight basis by using following formulae.

$$\text{Leaf area} = \frac{X \times a}{b \times c}$$

whereas,

X = Dry weight of total leaves of sampled plants

a = Leaf area of fifty leaves

b = Dry weight of fifty leaves

c = Total number of sampled plants

3.10.1.6 Leaf area index

Leaf area index represents a ratio of leaf area per plants to the land area occupied by plant, expressed in the same unit. LAI was worked out by using following formulae (Watson, 1947).

$$LAI = \frac{\text{Leaf area plant}^{-1}}{\text{Land area occupied by plant}}$$

3.10.1.7 Dry matter accumulation plant^{-1}

The dry matter accumulation plant^{-1} indicates vigour and growth of the plant. Plants from 50 cm row length in the first year and 25 x 25 cm square plot during the second year were cut from ground surface at seedling, 80% flowering and at harvest. Leaves and balls were plucked and stem was cut into small pieces and kept in the oven at 65 ^{0}C till the constant weight was obtained. Oven dry weight of different plant parts was recorded separately by weighing on automatic electric balance and average total dry matter accumulation plant^{-1} was worked out.

3.10.2 Root and nodulation

3.10.2.1 Number of nodules plant $^{-1}$

Plants from 50 cm long row and 25 x 25 cm square plot were drawn from a soil monolith of 60 x 30 and 30 x 30 cm upto a depth of 60 cm during first and second year respectively at seedling stage (about 30 days) and afterwards at 30 days interval upto 120 days (Four observations only). The soil block was then kept in 35 mesh sieve and washed with spray pump. The washing of root was done very gently to minimise the injury and detachment of nodules from the roots. After 4-5 washing, the nodules were plucked and placed between the layer of blotting paper. Nodule count was made after air drying for three hours. The average number of nodules was worked out by dividing the total number of nodules with total number of plants.

3.10.2.2 Dry weight of nodules plant $^{-1}$

After counting, nodules were dried in hot air oven at 65°C for 6 hours and weighed on automatic electric balance to work out mean dry weight of nodules plant $^{-1}$.

3.10.2.3 Dry weight of roots plant $^{-1}$

After separating nodules from the roots, all roots, were dried in hot air oven at 65 °C till the constant weight was obtained. Oven dry weight was recorded by weighing the roots on automatic electric balance and average was worked out.

3.11 Growth studies

The growth studies of plants includes the following physiological growth functions.

3.11.1 Relative growth rate (RGR)

Blackman (1919) pointed out that the increase in dry matter weight is a continuous process of compound interest rate and the increment in any interval adds to the 'capital' for subsequent growth. This rate of increment is called as relative growth rate (RGR) and is calculated by using the following equation given by Briggs et. al. (1920).

$$RGR = \frac{Log_e\ W2 - Log_e\ W1}{t_2 - t_1}$$

where, Log_e = natural logarithum, W1 and W2 are the dry weights at time (day) t_1 and t_2 respectively.

3.12 Days to flower initiation

Date of first flower appearance on observation plants in each plot was noted and number of days required for flower initiation were worked out.

3.13 Days to maturity

Maturity of crop in each plot was judged by visual observation. The date at which above ground biomass (leaves and balls etc.) of the observation plants was shed to the extent of appoximately 65 -75%, that date was recorded and average was worked out to know the days required for maturity.

Method of Seed collection per plant

PLATE - 4

Method of ground sweeping for seed collection

3.14 Post-harvest studies

3.14.1 Number of balls (flower heads) plant -1

One plant in first year and two plants during second year in each treatment, were covered with a netted cloth bag of size 50 x100 cm after flower initiation. Open end of the bag was closed by tying with stem near the ground surface. At frequent intervals balls (about to mature) were plucked, counted, and kept in the same bag (Plate, 3). The process was continued till the cop maturity. Average was worked out to know the number of balls plant $^{-1}$.

3.14.2 Weight of balls plant^{-1}

The balls collected in cloth bag were weighed on the automatic electric balance and average number of balls plant $^{-1}$ were worked out.

3.14.3 Number of seeds ball $^{-1}$

Fifty balls from each cloth bag were taken up to find out number of seeds ball $^{-1}$. Seeds were counted after removing the husk and mean was worked out.

3.14.4 Weight of seed ball $^{-1}$

All the seeds obtained from 50 balls were weighted on automatic electric balance and average was worked out to know the seed weight ball $^{-1}$.

3.14.5 Seed yield plant $^{-1}$

Seeds obtained from the 50 balls as wells as after threshing the balls, collected in cloth bag were weighed and seed yield plant $^{-1}$ was calculated.

3.14.6 Seed yield ha^{-1}

The seeds collected from the net area of each plot (after threshing and sweeping plate, 4) were sieved through 2 x 2 and 4 x 3 mm seive, cleaned and dried. The yield of observation plant was added to the net plot yield and weighed to find out seed yield per plot which was added to the net plot yield and weighed to find out seed yield per plot which was multiplied by a ha factor to worked out yield ha^{-1}.

3.14.7 Straw yield ha^{-1}

The straw from each net plot was dried, weighed and straw yield q ha^{-1} was calculated.

3.14.8 Harvest Index

The economic yield (seed) was divided by the biological yield (Total produce) and relationship was worked out and expressed in percentage as given below :

$$\text{Harvest index (\%)} = \frac{\text{Economic yield q ha}^{-1}}{\text{Biological yield q ha}^{-1}} \times 100$$

3.15 Quality studies

3.15.1 Test weight

For this purpose a small representative sample of seed from each treatment was drawn from the product after threshing and sweeping. One thousand seeds were counted, weighed with the help of automatic balance and weight was expressed as test weight (g).

3.15.2 Protein content in seed (%)

The seeds (0.5 g) from each net plot were ground by Willey's mill and preserved in properly labelled paper bag for protein estimation. The Samples were analysed to determine nitrogen percentage by modified KJeldahl's method (A.O.A.C., 1960). The nitrogen percentage was then multiplied by a constant 6.25 to obtained protein percentage in seed.

3.15.3 Seed germination

The seed germination was tested in a B.O.D Incubator at 32°C. Fifty seeds were counted and placed in sterlised petridishes in between two blotting papers in three replications and moisture was maintained continuously. Number of seeds germinated were counted on alternate day upto 15 days after placement. Statistical analysis was carried out by using angular transformation values.

3.16 Chemical studies

3.16.1 Analysis of plant samples

The plant samples collected from each plot at 80% flowering and at harvest stages for dry matter studies were air dried and then finally oven dried at 65°C till constant weights were obtained. Oven dried samples were ground in Willey's mill. From each sample 0.5 g was weighed separately for determination of N,P,K contents.

3.16.1.1 Nitrogen (%)

Nitrogen content in plant sample was determined by Kjeldahl's method as described by Jackson (1967).

3.16.1.2 Phosphorus (%)

Phosphorus determination was carried out in tri-acid extrract colorimetrically using vanado-molybdate-phsphoric yellow colour method (Jackson, 1967).

3.16.1.3 Potassium (%)

Potassium contents were determined by Flame photometer method (A.O.A.C., 1960) in tri-acid extract.

3.16.2 Nutrient yield ha^{-1}

The percentage of N, P and K in plant recorded at 80% flowering was multiplied by total dry weight plant^{-1} and plant population ha^{-1} under each treatment to know the treatmentwise uptake in kg ha^{-1}. Nutrient uptake was calculated by using following formulae.

$$\underset{(\text{Kg ha}^{-1})}{\text{Nutrient yield}} = \frac{\%\ \text{N, P, K}}{100} \times \begin{matrix}\text{Dry weight} \\ \text{plant}^{-1}\ (\text{g})\end{matrix} \times \begin{matrix}\text{Plant population} \\ \text{ha}^{-1}\ \text{of each plot}\end{matrix} \times \frac{1}{1000}$$

3.17 Soil properties

3.17.1 Chemical analysis of soil (Residual soil fertility status)

Treatmentwise soil samples were drawn from 0-30 cm depth after harvesting the crop in both the years. The samples were air dried and ground in a morter, sieved through 2 mm sieve, labelled and store in a cloth bag for chemical analysis.

3.17.1.1 Soil reaction

pH of 1:2 soil water solution was determined electrometrically using a pH meter as described by Jackson (1967).

3.17.1.2 Electircal conductivity (E.C.)

The clear supernatant extract obtained from the suspension used for pH was utilized for EC measurment using a conductivity bridge (Jackson, 1967).

3.17.1.3 Cation exchange capacity

The soil was saturated with 1 N sodium acetate (pH 8.2). The washings with sodium acetate was given to remove salts, followed by washings with alcohol to remove excess of sodium acetate. The absorbed sodium was extracted by washing with 1 N ammonium acetate (pH 7.0) and leachate was made upto known volume. Na^+ pressent in the leachate was determined with a flame-emission spectrophotometer (Richards, 1954).

3.17.1.4 Available nitrogen (kg ha^{-1})

It was estimated by alkaline potassium permanagenate method described by Subbiah and Asija (1956).

3.17.1.5 Availalbe Phosphrous (kg ha^{-1})

It was determined by Olsen's method with 0.5 M sodium bicarbonate extractant of pH 8.5 as described by Jackson (1967).

3.17.1.6 Available potassium (kg ha^{-1})

Avaliable potassium was determined by Fame-photometrically using neutral ammonium acetate as soil extractant (Jackson, 1967).

3.17.2 Determination of soil moisture (%)

The samples were drawn from 0-30 cm depth by screw auger from each plot in sample boxes and weighed for their fresh weight and then dried in oven at 105°C for 24 hours to record the dry weight. The moisture content in the soil was determined gravimetrically (Piper, 1966).

3.18 Statistical Analysis

Analysis of variance and test of significance

Experimental data recorded on various characters were pooled and analysed by adopting standard statical method of "Analysis of Variance" as advocated by Panse and Sukhatme (1967). The significance of treatment was tested with the help of variance ratio (F value). Critical difference (CD) was calculated at 5% level of probability for treatments comparision.

3.19 Graphical representation of data

The data obtained on various aspects under investigation were depicted through graphs, histograms and curves, developed by Haward Graphics on WIPRO GENIUS-456(T) Computer wherever necessary in order to illustrate the experimental findings.

3.20 Regression analysis of the yield data

The seed yield data pooled for two years were subjected to regression analysis to find out the relationship between the levels of input and the yield of seed.

3.20.1 Production Function

The relationship between the levels of input and corresponding output is called as production function. Experimental data was not found qualified for fitting the two variable quadratic equation. Simple quadratic quation of the following type was fitted for P_2O_5 separately at respective sowing treatments.

$$\hat{Y} = a + bx + cx^2$$

whereas,

$\hat{Y}$ = predicted yield q ha^{-1}

a,b,c = constant values

x = levels of input

3.20.2 Response curve

When the output is related to variation in the levels of single factor keeping other factor constant a response curve is obtained. Response equations were developed and the curves were drawn accordingly.

3.20.3 Maximum predicted yield

Predicted yield for phosphorus was calculated separately by using the following quadratic equation.

$$x = \frac{b}{(-)\ 2c}$$

whereas,

b,c = constant values

x = levels of input

3.20.4 Optimum input levels for P_2O_5

Optimum input levels for P_2O_5 calculated separately as per present price situation, of styloseed and single superphosphate by using following formulae.

$$\text{Optimum dose} = \frac{1}{(-)\ 2c}\left(\frac{q}{p} - b\right)$$

Where 'q' and 'p' correspond to cost per unit of P_2O_5 and onequintal of stylo seed respectively. In the present study one unit of P_2O_5 was presumed as 25 kg over and above the base level at Rs. 396.75 price level. Cost of stylo seed was considered as Rs. 45.0 kg^{-1}. On the basis of this predicted yields at optimum input levels were calculated.

3.21 Economics of seed production

Expenditure and total monetory returns were worked out at the previling market rates of nitrogen, P_2O_5, K_2O, stylo seed and other operations as stated in Table 4 and 4(a). From these figures, net profit (Rs. ha^{-1}) was calculated for each treatment. The net return per rupee investment was worked out by dividing, total net return with the total const involved in raising the crop. The gross and net as well as net return per rupee investment (B.C.Ratio) for each treatment were worked out as follows.

i) Gross return (Rs ha^{-1}) = Cost of stylo seed

ii) Net return (Rs ha^{-1}) = Gross return (Rs ha^{-1}) - total expenditure (Rs ha^{-1})

iii) Net return per rupee investment = Net return (Rs. ha^{-1}) $\div$ total expenditure (Rs. ha^{-1})

Table 4: Statement showing the prices in Rs. unit^{-1} for various operations

Sr. No.	Particulars	Price Unit^{-1} (Rs.)	
		1994-95	1995-96
1.	Ploughing by tractor	550 ha^{-1}	--
2.	Harrowing by tractor	70 ha^{-1}	--
3.	Bullock pair	80 day^{-1}	--
4.	Labour charge (M/F)	40 day^{-1}	40 day^{-1}
5.	Seed	45 kg^{-1}	--
6.	Thirum	150 kg^{-1}	--
7.	Nitrogen	6.41 kg^{-1}	6.41 kg^{-1}
8.	P_2O_5	15.87 kg^{-1}	15.87 kg^{-1}
9.	K_2O	6.86 kg^{-1}	6.86 kg^{-1}

3.21.1 Incremental benefit-cost ratio (B.C. ratio)

Incremental benefit cost ratio is commonly used in working the economics of fertilizer used. According to Patel (1975), it is a decision making tool which can be applied in evaluating profitability of using certain doses of fertilizer for enhancement of crop yields.

Table 4 (a) : Statement showing the items of cost at various treatments (Rs.)

Sr. No. Particulars	1994-95				1995-96			
	D1	D2	D3	D4	D1	D2	D3	D4
A. 1. Ploughing by tractor	550	550	550	550	-	-	-	-
2. Harrowing and levelling by tractor	280	280	280	280	-	-	-	-
3. Harrowing by bullock pair	-	200	200	200	-	-	-	-
4. Cleaning and layout	240	300	320	380	560	480	420	400
5. Sowing	320	320	320	320	-	-	-	-
6. Fertilizer application	200	200	200	200	200	200	200	200
7. Gapfilling / thinning	360	320	220	160	440	360	300	280
8. Weeding	3480	3100	1060	1000	2400	2240	2120	2080
9. Harvesting, tying of bundles, threshing, sweeping, sieveing drying & packing	5640	5240	3440	2540	6440	5800	4240	4200
10. Urea	134	134	134	134	-	-	-	-
11. Single superphosphate	597	597	597	597	597	597	597	597
12. Muriate of potash	618	618	618	618	618	618	618	618
13. Seed and seed treatment with thirum	272	272	272	272	-	-	-	-
B. 14. Interest on working capital @ Rs. 12 per annum for six months growing period								
Cost 'A' (A+B)								
C. 15. Land rent (1/6 th of the total value of produce)								
Cost 'B' (A+B+C)								

CHAPTER - IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

An experiment entitled "**Effect of sowing time and levels of phosphorus and potash on seed production in *Stylosanthes hamata* (L.) cv Verano**" was conducted during Kharif 1994-95 and 1995-96 at Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi. During the course of experimentation the observations recorded on plant growth as well as yield and yield attributes of *S. hamata,* as influenced by various factors have been presented in this chapter. Sowing time has its own importance and has ultimate effect on vegetative growth and production potential of a crop. This was examined under main plot treatments. Since phosphorus and potash levels were tested in sub plot treatments, information on phosphorus and potassium contents in plant at various growth stages were estimated and are given here. Besides yield data, quality characters are equally important which were studied and the data are included here. Lastly, in such a study monetory returns are important. The values of relative economics of production are calculated to provide information on the profitability of various treatments.

4.1 Pre - harvest studies

4.1.1 Plant population

The plant population at initial as well as at harvest, recorded during both the years and when the data were pooled are presented in Table 5.

Data indicated that, initial mean plant population was 5.76 m^{-2} (57600 ha^{-1}) during 1994-95, which subsequently increased to 46.10 m^{-2} (461000 ha^{-1}) in the year 1995-96. The corresponding pooled value was 25.92 m^{-2} (259200 ha^{-1}). At harvest, mean plant population was observed to be 5.68 m^{-2} (56800 ha^{-1}) during 1994-95 and 44.88 m^{-2} (448800 ha^{-1}) during 1995-96. Pooled data indicated 25.28 plant m^{-2} (252800 ha^{-1}) at this stage. It was further observed that, mean plant population was nearly eight times higher during second year than that recorded in the initial seeding year.

Effect of sowing

Data indicated profound effect of various sowings on plant population throughout the study. In 1994-95 and 1995-96, under early sowings at first followed by second date, there was significantly higher plant population initially as well as at harvest, as compared to other sowings. The delay in sowing (third and last) resulted drastic reduction in plant population and the lowest being the last. First and second sowings were at par with each other. Pooled data indicated similar trend and plant population at initial as well as at harvest was found to be decreasd by 38.5, 37.37 % and 54.86, 53.68% respectively in third as well as last sowing over the first date.

Effect of P_2O_5

Graded levels of P_2O_5 did not show significant influence on plant population at both stages, during both the years and also when the data was pooled.

Table 5 : Mean plant population at initial and at harvest as influenced by various treatments

Treatments	Initial				Harvest				Initial		Harvest	
	m^{-2}		ha^{-1}		m^{-2}		ha^{-1}		m^{-2}	ha^{-1}	m^{-2}	ha^{-1}
	94	95	94	95	94	95	94	95	Pooled			
Sowing time												
D1	7.40	61.10	74000	611000	7.25	58.95	72500	589500	34.25	342500	33.10	331000
D2	7.26	58.70	72600	587000	7.20	56.72	72000	567200	32.98	329800	31.96	319600
D3	4.90	37.16	49000	371600	4.84	36.62	48400	366200	21.03	210300	20.73	207300
D4	3.48	27.44	34800	274400	3.43	27.23	34300	272300	15.46	154600	15.33	153300
S.E. (m) ±	0.11	0.85	1100	8500	0.10	0.76	1000	7600	0.43	4300	0.38	3800
C.D. at 5%	0.35	2.72	3500	27200	0.31	2.41	3100	24100	1.27	12700	1.14	11400
Levels of phosphate												
P0	5.74	45.84	57400	458400	5.65	44.57	56500	445700	25.79	257900	25.11	251100
P1	5.75	46.07	57500	460700	5.68	44.80	56800	448000	25.91	259100	25.24	252400
P2	5.76	46.20	57600	462000	5.69	45.03	56900	450300	25.98	259800	25.36	253600
P3	5.79	46.29	57900	462900	5.70	45.12	57000	451200	26.04	260400	25.41	254100
S.E. (m) ±	0.05	0.56	500	5600	0.03	0.49	300	4900	0.28	2800	0.24	2400
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Levels of potash												
K0	5.73	45.89	57300	458900	5.66	44.72	56600	447200	25.81	258100	25.19	251900
K1	5.76	46.00	57600	460000	5.67	44.79	56700	447900	25.88	258800	25.23	252300
K2	5.77	46.23	57700	462300	5.61	44.97	56900	449700	26.00	260000	25.33	253300
K3	5.78	46.28	57800	462800	5.70	45.04	57000	450400	26.03	260300	25.37	253700
S.E. (m) ±	0.05	0.56	500	5600	0.03	0.49	300	4900	0.28	2800	0.24	2400
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	5.76	46.10	57600	46100	5.68	44.88	56800	448800	25.92	259200	25.28	252800

Table 6 : Mean plant population at initial (old plants + new seedlings) as influenced by various treatments during 1995 - 96

Treatments	Old plants of 1994 - 95		%	New seedlings of 1995 - 96		Total plant population	
	m^{-2}	ha^{-1}	Survival	m^{-2}	ha^{-1}	m^{-2}	ha^{-1}
Sowing time							
D1	1.17	11700	16	59.93	599300	61.10	611000
D2	1.08	10800	15	57.62	576200	58.70	587000
D3	0.85	8500	17	36.31	363100	37.16	371600
D4	0.66	6600	19	26.78	267800	27.44	274400
Levels of phosphate							
P0	0.92	9200	17	44.92	449200	45.84	458400
P1	0.90	9000	16	45.17	451700	46.07	460700
P2	1.03	10300	18	45.17	451700	46.20	462000
P3	0.98	9800	17	45.31	453100	46.29	462900
Levels of potash							
K0	0.91	9100	16	44.98	449800	45.89	458900
K1	0.94	9400	17	45.06	450600	46.60	466000
K2	0.92	9200	16	45.31	453100	46.23	462300
K3	1.01	10100	18	45.27	452700	46.28	462800

Effect of K_2O

Application of graded doese of K_2O also had no significant effect on plant population throughout the study.

Interaction

None of the interactions influenced plant population significantly neither in any individual year nor when the data was pooled.

4.2 Growth studies

4.2.1 Plant height

The data pertaining to plant height are presented in Table 7. From these results, it appears that the mean plant height at seedling stage was increased from 11.02 to 61.84 cm at harvest in 1994-95 and from 12.95 to 73.04 cm in 1995-96. The corresponding increase being from 11.99 to 67.44 cm when the data were pooled. Maximum rate of increase in plant height was noted in between seedling to 80 % flowering stage (46.42, 56.07 and 51.25 cm, in first year, second year and in pooled data, respectively). The rate of increase was decreased with advancing crop age and the lowest being between the period from 80 % flowering to harvest (4.40, 4.14 and 4.20 cm, in first year, second year and in pooled data, respectively).

Effect of sowing

The data pertaining to plant height showed significant variation due to various sowings at all growth stages, except during second year. In 1994-95, first sowing followed by second, found to be significantly superior than all sowings at all stages and attained maximum height (68.31 and 66.85 cm) at harvest stage. The variaiton in third sowing was also significantly more than that in the last at all stages. Both earlier sowings

Table 7 : Height plant $^{-1}$ (cm) as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	12.55	62.76	68.31	13.30	70.74	74.63	12.92	66.75	71.47
D2	11.90	61.89	66.85	13.11	69.66	73.48	12.50	65.77	70.16
D3	10.62	57.13	61.64	12.80	68.81	72.26	11.71	62.97	66.95
D4	9.04	48.01	50.58	12.62	66.89	71.29	10.83	57.45	60.93
S. E. (m) ±	0.25	1.34	1.52	0.28	1.51	1.59	0.18	1.01	1.10
C. D. at 5%	0.79	4.27	4.89	N.S.	N.S.	N.S.	0.54	3.01	3.30
Levels of phosphate									
P0	10.77	56.13	60.15	12.74	67.86	71.75	11.75	61.99	65.95
P1	11.05	57.52	61.48	12.80	69.08	72.32	11.92	63.30	66.90
P2	11.10	57.71	62.65	13.12	69.37	73.77	12.11	63.54	68.21
P3	11.19	58.43	63.10	13.17	69.79	73.82	12.18	64.11	68.46
S.E. (m) ±	0.21	1.21	1.36	0.24	1.23	1.31	0.16	0.86	0.94
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Levels of potash									
K0	10.80	56.69	60.59	12.82	67.93	71.90	11.81	62.31	66.24
K1	10.99	57.11	61.95	12.92	68.98	73.14	11.95	63.04	67.54
K2	11.14	57.79	62.12	12.99	69.06	73.44	12.06	63.42	67.78
K3	11.18	58.20	62.79	13.10	70.13	74.18	12.14	64.16	68.45
S.E. (m) ±	0.21	1.21	1.36	0.24	1.23	1.31	0.16	0.86	0.94
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	11.02	57.44	61.84	12.95	69.02	73.04	11.99	63.24	67.44

were almost similar in their effects. Thus there was significant reduction in plant height due to delay in sowings during this year. However in 1995-96, sowing treatments did not incfluenced plant height significantly at all stages of growth. Pooled data however revealed almost increasing trend in plant height with earliness in sowing. Plantheight was significantly higher in first sowing at all stages of growth and was maximum (71.47 cm) at harvest, amongst all sowings except second. Similarly, second sowing (70.16 cm) had also higher plant height than third sowing at seedling stage and than the last sowing at all stages. Third sowing was also better in plant height than the last. Data further revealed that, first sowing with second at all stages and second sowing with third at 80 % flowering as well as at harvest were similar in their effects.

Effect of P_2O_5

Increasing levels of P_2O_5 from P0 to P3 had no significant influence on plant height throughout the study.

Effect of K_2O

During both the years and in pooled data also, plant height did not show significant variation due to K_2O application.

Interaction

Interaction effects were non significant throughout the investigation.

4.2.2 Stem diameter

The data on stem diameter plant^{-1} are presented in Table 8. From the data it appears that, mean stem diameter plant $^{-1}$ increased upto harvest, which was 4.345 mm in 1994-95 iand 3.317 mm during 1995-96.

The corresponding pooled value was 3.831 mm plant $^{-1}$. The rate of increase was highest between seedling to 80% flowering stage (2.565, 2.001 and 2.263 mm, in first year, second year and in pooled data, respectively) and found to be decreased thereafter.

Effect of sowing

Stem diameter plant^{-1} found to be significantly increased due to various sowings throughout the study, but seedling stage onwards only. In the first year, both early sowings (first followed by second) proved significantly superior at all stages (80% flowering and at harvest) and recorded maximum stem diameter at harvest (4.913 and 4.840 mm, respectively) as compared to other sowings, but were similar in performance with each other. Similarly, third sowing was also better than the last at these stages. In second year, the data showed opposite trend of results to that recorded in the initial year. Stem diameter was found to be increased in the late treatments, but differences within all treatment did not show significant variation. Perusal of pooled data indicated almost superiority of both earlier sowings (first followed by second), which were at par with each other at 80% flowering and at harvest, but had significantly highest stem diameter plant^{-1} (4.086 & 4.054 mm, respectively) than third and last sowing. Third was also significantly superior over the last sowing.

Effect of P_2O_5

Application of P_2O_5 favourably influenced stem diameter throughout the study. In the initial stage, (seedling) there were no significant differences among the treatments. During both the years, higher dose at P3 followed by P2 proved significantly superior over unfertilized treatment, but

Table 8 : Stem diameter plant^{-1} (mm) as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	1.306	4.385	4.913	1.070	3.001	3.260	1.188	3.693	4.086
D2	1.290	4.175	4.840	1.081	3.021	3.269	1.185	3.598	4.054
D3	1.273	3.790	4.254	1.090	3.056	3.344	1.181	3.423	3.799
D4	1.233	3.031	3.373	1.121	3.106	3.397	1.177	3.068	3.385
S. E. (m) ±	0.025	0.081	0.092	0.022	0.049	0.058	0.017	0.047	0.054
C. D. at 5%	N.S.	0.258	0.292	N.S.	N.S.	N.S.	N.S.	0.143	0.164
Levels of phosphate									
P0	1.259	3.685	3.963	1.072	2.895	3.009	1.165	3.290	3.486
P1	1.272	3.815	4.334	1.090	3.034	3.269	1.181	3.424	3.801
P2	1.281	3.930	4.535	1.096	3.113	3.467	1.188	3.521	4.001
P3	1.290	3.951	4.548	1.104	3.142	3.525	1.197	3.546	4.036
S.E. (m) ±	0.20	0.059	0.068	0.018	0.052	0.060	0.013	0.039	0.045
C.D. at 5%	N.S.	0.163	0.187	N.S.	0.144	0.166	N.S.	0.110	0.125
Levels of potash									
K0	1.258	3.790	4.298	1.080	3.026	3.269	1.169	3.408	3.783
K1	1.275	3.840	4.343	1.085	3.043	3.314	1.180	3.441	3.828
K2	1.278	3.865	4.364	1.092	3.054	3.336	1.185	3.459	3.850
K3	1.291	3.886	4.375	1.105	3.061	3.351	1.197	3.473	3.863
S.E. (m) ±	0.020	0.059	0.068	0.018	0.052	0.060	0.013	0.039	0.045
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	1.275	3.840	4.345	1.090	3.046	3.317	1.182	3.445	3.831

were at par with each other and also with P1 at 80 % flowering stage. However, at harvest, both these treatments (P2 and P3) were almost superior over rest of the treatments and remained at par with each other. Treatment P1 was found at par with control treatment at 80 % flowering stage, but with advancement in crop age, it proved superior over control. Significant increase in stem diameter was also noted when the data was pooled. With each successive increase in P_2O_5 level, there was significant increase in stem diameter over preceeding level, except P3, which was at par with P2 at 80 % flowering as well as at harvest stage also.

Effect of K_2O

In 1994-95, 1995-96 and when the data was pooled, K_2O failed to register its influence on stem diameter at all stages and at all levels.

Interaction

Interaction effects were non significant throughout the study.

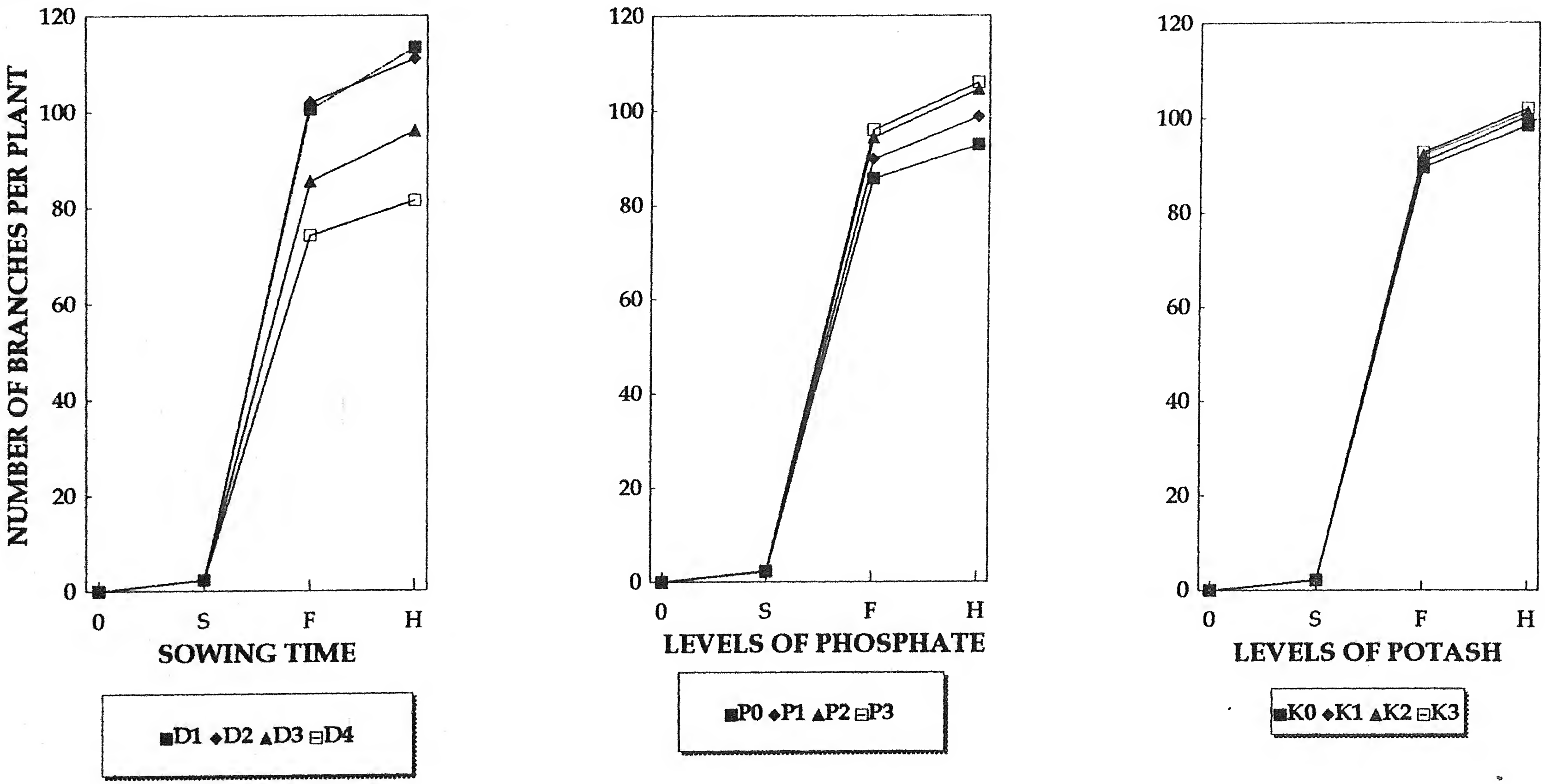
4.2.3 Number of branches

Data regarding mean number of branches plant^{-1} are presented in Table 9 and graphically depicted in Fig. 6.

The results indicated that the number of branches increased progressively with increase in the age of crop and attained maximum at harvest stage. (105.99, 94.95 and 100.47, in first year, second year and in pooled data, respectively). The rate of production of branches was maximum between seedling to 80 % flowering stage (92.87, 85.33, 88.46, in first year, second year and in pooled data, respectively) and declined thereafter during both the years.

Table 9 : Number of branches plant^{-1} as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	2.49	123.22	134.86	1.94	83.72	91.71	2.21	103.47	113.28
D2	2.48	118.75	129.58	1.95	85.16	92.35	2.21	101.95	110.96
D3	2.41	82.32	96.40	1.99	88.73	95.72	2.20	85.52	96.06
D4	2.38	56.97	63.12	2.03	91.65	100.01	2.20	74.31	81.56
S. E. (m) ±	0.05	2.21	2.49	0.04	1.99	2.25	0.032	1.49	1.68
C. D. at 5%	N.S.	7.09	7.94	N.S.	6.37	7.18	N.S.	4.44	5.05
Levels of phosphate									
P0	2.40	90.03	98.14	1.93	81.15	87.50	2.16	85.59	92.82
P1	2.42	93.54	104.35	1.98	86.09	93.03	2.20	89.81	98.69
P2	2.46	97.91	110.31	1.99	90.85	98.66	2.22	94.38	104.48
P3	2.48	99.78	111.16	2.02	91.17	100.60	2.23	95.97	105.88
S.E. (m) ±	0.04	1.82	2.09	0.03	1.53	1.79	0.027	1.20	1.37
C.D. at 5%	N.S.	5.04	5.78	N.S.	4.24	4.96	N.S.	3.29	3.83
Levels of potash									
K0	2.39	93.18	103.45	1.96	85.97	93.52	2.17	89.57	98.48
K1	2.44	94.65	105.88	1.97	86.87	94.75	2.20	90.76	100.31
K2	2.46	96.36	107.14	1.99	87.92	95.11	2.22	92.14	101.12
K3	2.47	97.07	107.49	2.00	88.50	96.41	2.23	92.78	101.95
S.E. (m) ±	0.04	1.82	2.09	0.03	1.53	1.79	0.027	1.20	1.37
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	2.44	95.31	105.99	1.98	87.31	94.94	2.20	90.66	100.47



S - SEEDLING F - 80 % FLOWERING H - HARVEST

FIG. 6: NUMBER OF BRANCHES PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS AT DIFFERENT GROWTH STAGES

Effect of sowing

Substantial effect of sowing treatments was observed on number of branches plant^{-1} during both the years and when the data was pooled. Treatment differences were not discernible at seedling stage, but with increase in crop age, number of branches plant^{-1}, found to be significantly increased due to various sowings. In 1994-95, the earliest sowing, first followed by second, produced significantly more branches plant^{-1} at 80 % flowering as well as at harvest than rest of the sowings. Third sowing was also better than the last at these stages. In 1995-96, last treatment proved consistantly superior over first and second at both the stages and produced significantly more branches, but did not differ with third. Similarly, first and second also did not differ with third at these stages.Thus, during first year, total number of branches found to be increased with early sowings and were significantly maximum in first (134.86) followed by second (129.58), which were at par with each other. on the contrary, during second year branches produciton hastened in delayed treatment and were maximum in the last (100.01). However, when the data was pooled, increasing trend was noted with early sowings and first (113.28) followed by second (110.96), showed significantly more branches amongst all, but remained at par with each other. Branches produciton decreased significantly thereafter as in the third and lowest in the last sowing.

Effect of P_2O_5

Application of P_2O_5 produced significant influence on total number of branches plant^{-1} and the effects being more pronounced at seedling stage onwards. Treatment P3 followed by P2, which were at par with each other, recorded significant increase in number of branches over unfertilized

treatment, and P3 also over P1 at 80% flowering stage during first year. Unfertilized treatment was lowest amongst all, but was at par with P1 and further P1 to P2 also at this stage. However, at harvesting stage in the first year and from 80% flowering stage during second year and when the data was pooled, P3 followed by P2 produced significantly more branches than all treatments. Similarly, P1 also showed significantly higher branches than unfertilized treatment at this stage. Maximum number of branches at highest stage of growth were observed to be in P3 (105.88) followed by P2 (104.48) treatments, which were almost at par with each other throughout the study.

Effect of K_2O

Graded levels of K_2O had no significant effect on number of branches plant^{-1} throughout the experimentation.

Interaction

Interaction effects on number of branches plant^{-1} were non significant throughout the study.

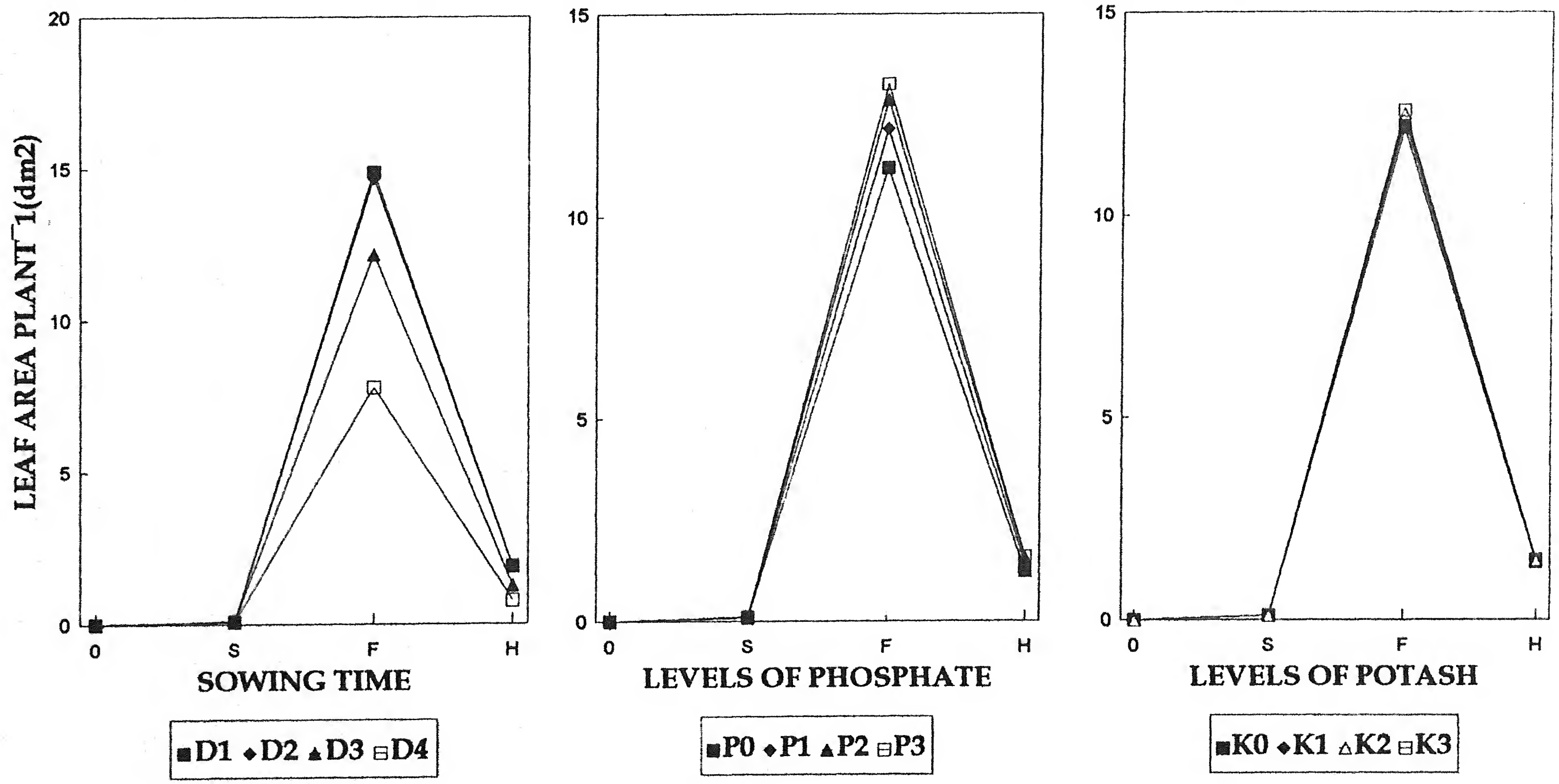
4.2.4 Leaf area

Data on leaf area plant^{-1} estimated in different treatments at various growth stages are presented in Table 10 and graphically shown in fig. 7.

It was observed from the data that, mean leaf area plant^{-1} increased progressively upto 80% flowering stage (18.950, 5.813 and 12.384 dm^2, respectively, during first year, second year and when the data was pooled) and subsequently dropped down throughtout the study. The rate of increase was maximum between seedling to 80 %flowering stage (18.830, 5.735 and 12.285 dm^2, in first year, second year and on pooled basis, respectively).

Table 10 : Leaf area plant^{-1} (dm^2) as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	0.137	24.904	3.200	0.070	4.870	0.538	0.103	14.887	1.869
D2	0.131	24.274	3.161	0.074	5.106	0.555	0.102	14.690	1.858
D3	0.124	17.752	1.851	0.082	6.580	0.617	0.103	12.166	1.234
D4	0.091	8.873	0.861	0.088	6.710	0.648	0.089	7.791	0.754
S. E. (m) ±	0.0026	0.451	0.043	0.002	0.127	0.011	0.0019	0.234	0.022
C. D. at 5%	0.0082	1.440	0.136	0.007	0.404	0.035	0.0056	0.704	0.067
Levels of phosphate									
P0	0.118	17.087	1.907	0.076	5.325	0.510	0.097	11.206	1.208
P1	0.120	18.680	2.218	0.078	5.642	0.568	0.099	12.161	1.393
P2	0.122	19.745	2.456	0.079	6.038	0.633	0.100	12.891	1.544
P3	0.123	20.291	2.492	0.081	6.265	0.647	0.102	13.278	1.569
S.E. (m) ±	0.0022	0.330	0.037	0.0018	0.106	0.013	0.0018	0.173	0.019
C.D. at 5%	N.S.	0.914	0.103	N.S.	0.291	0.036	N.S.	0.482	0.055
Levels of potash									
K0	0.119	18.570	2.233	0.077	5.699	0.576	0.098	12.134	1.404
K1	0.120	18.887	2.257	0.078	5.802	0.584	0.099	12.344	1.420
K2	0.121	19.115	2.280	0.079	5.866	0.596	0.100	12.490	1.438
K3	0.123	19.231	2.303	0.080	5.903	0.602	0.101	12.567	1.452
S.E. (m) ±	0.0022	0.330	0.037	0.0018	0.106	0.013	0.0018	0.173	0.019
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	0.120	18.950	2.268	0.078	5.813	0.589	0.099	12.384	1.428



S- SEEDLING F- 80 % FLOWERING H- HARVEST

FIG.7. LEAF AREA PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENT AT DIFFERENT GROWTH STAGES.

The rate of increase, decreased thereafter due to senancence of leaves (16.682, 5.224 and 10. 956 dm^2, in first year, second year and on pooled basis respectively). Data further indicated that, leaf area $plant^{-1}$ during first year was three times more than that recorded during the second year of study.

Effect of sowing

As observed from the data, sowing treatments had significant influence on leaf area $plant^{-1}$ throughout the growth stages. In 1994-95, leaf area $plant^{-1}$ was found to be increased due to early sowing. At seedling stage, first sowing had higher leaf area $plant^{-1}$ than that in the third and the last, but was similar to the second sowing. Similarly, second and third sowings were similar with each other in their effects but recorded more leaf area than the last at this tage. However, at latter stages (80% flowering and harvest) both early sowings (first followed by second) proved significantly superior and attained maximum leaf area (24.904 and 24.274 dm^2 respectively) than all treatments. Third sowing had also higher leaf area $plant^{-1}$ than the last at all stages. Contrary to this in 1995-96, last followed by third treatment showed significantly higher leaf area $plant^{-1}$ than first and second throughout the crop growth. But both earlier and both latter sowings did not differ within themselves. Leaf area was maximum at 80% flowering stage in last (6.710 dm^2) followed by third (6.580 dm^2). Thus there was increase in leaf area $plant^{-1}$ due to delayed sowings during this year. Pooled data revealed significant influence of all earlier three sowings over last at seedling stage but at par with one another. At rest of the stages, each early sowing recorded significantly higher leaf area $plant^{-1}$ than each delayed sowing

except second, which was at par with first. Amongst all sowings leaf area plant^{-1} was significantly more in first (1.869 dm^2) and second sowing (1.858 dm^2) which proved almost similar in effect.

Effect of P_2O_5

Graded levels of P_2O_5 significantly influenced leaf area plant^{-1}, but seedling stage onwards thoughout the study. As the level of P_2O_5 increased from P0 to P2, there was significant increase in leaf area plant^{-1} at 80% flowering and at harvest. Subsequent increament of P_2O_5 did not increase leaf area plant^{-1} significantly over P2, but was higher amongst all treatments. The maximum values in leaf area plant^{-1} recorded by P3 followed by P2 treatments were found to be 1.589 and 1.544 dm^2 respectively.

Effect of K_2O

Application of K_2O did not produced significant influence on leaf area plant^{-1} at any stage of crop growth throughout the experimentation.

Interaction

Interaction effects were non significant in 1994-95, 1995-96 and also when the data ~~was~~ were pooled.

4.2.5 Leaf area index

Data pertaining to LAI are presented in Table 11. The data revealed that, leaf area index was found to be progressively increased upto 80% flowering stage throughout the study (1.110, 2.577 and 1.840, in first year, second year and in pooled data respectively). The highest rate of increase was noted in between seedling to 80% flowering stage (1.103, 2.541 and 1.818, in first year, second year and in pooled data respectively.)

Table 11 : Leaf area index as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	0.0101	1.805	0.232	0.0427	2.871	0.317	0.0264	2.338	0.274
D2	0.0095	1.747	0.227	0.0434	2.896	0.314	0.0264	2.321	0.270
D3	0.0061	0.859	0.089	0.0304	2.411	0.226	0.0182	1.635	0.157
D4	0.0032	0.304	0.029	0.0241	1.827	0.176	0.0136	1.065	0.102
S. E. (m) ±	0.00020	0.028	0.0030	0.0008	0.061	0.0055	0.00041	0.033	0.0031
C. D. at 5%	0.00062	0.089	0.0093	0.0025	0.195	0.017	0.0012	0.101	0.0094
Levels of phosphate									
P0	0.0068	0.965	0.107	0.0348	2.374	0.227	0.0208	1.669	0.167
P1	0.0069	1.061	0.126	0.0359	2.527	0.254	0.0214	1.794	0.190
P2	0.0070	1.125	0.140	0.0365	2.719	0.284	0.0217	1.922	0.212
P3	0.0071	1.154	0.142	0.0375	2.827	0.292	0.0223	1.990	0.217
S.E. (m) ±	0.00015	0.022	0.0024	0.00068	0.050	0.0044	0.00036	0.029	0.0026
C.D. at 5%	N.S.	0.060	0.0066	0.0019	0.138	0.0122	0.00099	0.080	0.0073
Levels of potash									
K0	0.0068	1.051	0.126	0.0353	2.548	0.0259	0.0210	1.799	0.192
K1	0.0069	1.071	0.127	0.0358	2.599	0.0262	0.0213	1.835	0.194
K2	0.0069	1.087	0.129	0.0365	2.638	0.0268	0.0217	1.862	0.198
K3	0.0071	1.096	0.131	0.0370	2.659	0.0271	0.0220	1.877	0.201
S.E. (m) ±	0.00015	0.022	0.0024	0.00068	0.050	0.0044	0.00036	0.029	0.0026
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	0.0069	1.110	0.133	0.0358	2.577	0.260	0.0214	1.840	0.197

and decreaed drastically thereafter (0.997 in first year, 2.448 in second year and 1.643 in pooled data).

Effect of sowing

Data revealed that, first followed by second sowing had significantly higher LAI at all stages over rest of the treatments thoroughout the study. Each subsequent dalay thereon, loweered LAI significantly over preceeding sowing and being lowest in the last. However, both earliest sowings were similar in LAI throughout the study. The maximum LAI was recorded at 80% flowering stage which was119.0 and 117.0% more in first and second sowing respectively over that in the last.

Effect of P_2O_5

Graded levels of P_2O_5 significantly influenced LAI throughout the study except seedling stage in first year. However, in subsequent year and in pooled data, P_2O_5 at higher rate of P3 showed significant increase in LAI over unfertilized treatment but remained at par with other levels of P1 and P2 . At 80% flowering and at harvest throughout the study, each successive increase in P_2O_5 level, increased LAI significantly over the preceeding level except P3 which was at par with P2 treatment.

Effect of K_2O

Significant influence of K_2O was not recorded on LAI during both the years and when the date was pooled.

Interaction

Interaction effects were non significant during the course of study.

4.2.6 Dry matter accumulation

Data regarding dry matter accumulation plant^{-1} are presented in Table 12 and depicted in Fig. 8.

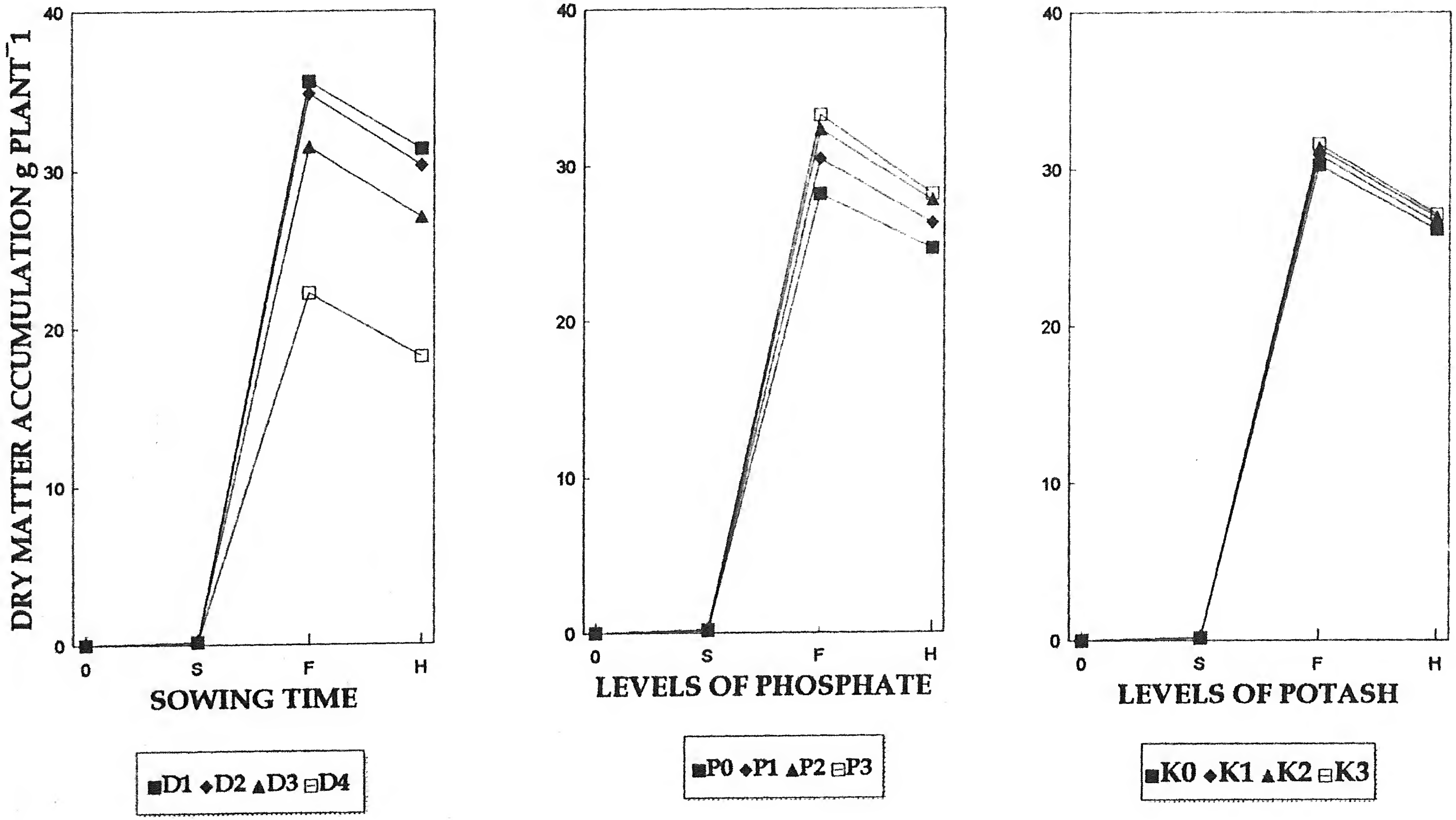
It is observed that, mean dry matter accumulation plant^{-1} increased progressively from seedling stage (0.183, 0.132 and 0.157 g, in first year, second year and in pooled respectively) to 80% flowering (44.938, 17.118 and 31.028g, in first year, second year and in pooled respectively) throughout the study. The rate of increase was maximum upto 80% flowering stage (44.755, 16.986 and 30.871g respectively) and declined subsequently (5.828, 2.859 and 4.347g respectively). It was noted that, the dry matter accumulation plant^{-1} during first year was more than twice than that recorded in the second year.

Effect of Sowing

Dry matter accumulation was significantly influenced due to various sowings at all stages throughout the study. In 1994-95, it increased significantly at all stages due to early sowings and was maximum at 80% flowering stage in first (56.248 g) followed by second (53.818 g) sowing than rest of the treatments. But both these treatments were at par with each other. Dry matter accumulation in third sowing was similar to that in second at seedling stage but was significantly higher than last sowing at this stage as well as at other stages also. In 1995-96, significant increase in dry matter accumulation was found in the delayed treatments. At seedling stage, differences due to sowings were non significant. But at 80% flowering and at harvest, last followed by third sowing produced significantly more dry matter than first and second. However, first and second, as well as third and last, did not differ among themselves at these stages. Maximum and significantly more dry matter plant^{-1} was observed in the last (19.250 g) followed by third

Table 12 : Dry matter accumulation plant^{-1} (g) as influenced by various treatments at different growth stages

Treatments	1994 - 95			1995 - 96			Pooled		
	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest	Seedling	80% Flowering	Harvest
Sowing time									
D1	0.201	56.248	49.624	0.124	14.936	12.970	0.162	35.592	31.297
D2	0.193	53.818	47.451	0.129	15.830	13.101	0.161	34.824	30.276
D3	0.180	44.462	38.808	0.135	18.458	15.160	0.157	31.460	26.984
D4	0.160	25.224	20.559	0.141	19.250	15.806	0.150	22.237	18.182
S. E. (m) ±	0.005	1.103	0.910	0.0035	0.456	0.239	0.0030	0.696	0.470
C. D. at 5%	0.015	3.526	2.911	N.S.	1.457	0.764	0.0092	2.086	1.411
Levels of phosphate									
P0	0.179	41.297	36.208	0.129	15.014	13.072	0.154	28.155	24.640
P1	0.182	44.040	38.404	0.131	16.822	14.101	0.156	30.431	26.252
P2	0.186	46.517	40.655	0.134	18.072	14.827	0.160	32.294	27.741
P3	0.187	47.898	41.175	0.136	18.566	15.037	0.161	33.232	28.106
S.E. (m) ±	0.004	0.848	0.781	0.0029	0.330	0.249	0.0025	0.569	0.410
C.D. at 5%	N.S.	2.347	2.162	N.S.	0.912	0.691	N.S.	1.575	1.137
Levels of potash									
K0	0.178	43.853	38.441	0.130	16.692	13.880	0.154	30.272	26.160
K1	0.184	44.781	38.845	0.132	17.050	14.242	0.158	30.915	26.543
K2	0.185	45.357	39.450	0.134	17.297	14.355	0.159	31.327	26.902
K3	0.187	45.761	39.706	0.135	17.435	14.560	0.161	31.598	27.133
S.E. (m) ±	0.004	0.848	0.781	0.0029	0.330	0.249	0.0025	0.569	0.410
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	0.183	44.938	39.110	0.132	17.118	14.259	0.157	31.028	26.681



S- SEEDLING F- 80 % FLOWERING H- HARVEST

FIG.8: DRY MATTER ACCUMULATION PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS AT DIFFERENT GROWTH STAGES.

(18.458 g) treatment in this year. Thus, dry matter accumulation $plant^{-1}$ was adversely affected by delay in sowing during first year, however, enhanced in the late sown treatments during second year. Pooled data revealed almost increasing trend in all stages of crop growth in early sowings. First followed by second sowing showed significant performance over rest of the treatments, except at seedling stage when both these treatments were similar to third but recorded maximum dry matter of 35.592 and 34.824 g $plant^{-1}$ respectively. Third sowing had also significantly higher dry matter than the last, but seedling stage onwards only. Thus, the data indicated decrease in dry matter accumulation $plant^{-1}$ to the tune of 55% in last sowing over first, during first year. However, it increased to the extent of 29.00 % in last sowing over first during second year. On pooled basis it was reduced by 37.72% in the delayed sowing of last date over first.

Effect of P_2O_5

Effect of P_2O_5 on dry matter accumulation was found to be significant, but seedling stage onwards throughout the study. Each successive increase in P_2O_5 level brought significant increase in dry matter $plant^{-1}$ except P3 treatment, as it (P3) failed to increase dry matter significantly over its lower level of P2.

Effect of K_2O

Application of K_2O did not increase dry matter $plant^{-1}$ significantly throughout the study.

Interaction

Interaction effects were non significant throughout the study.

4.2.7 Relative growth rate

Relative growth rate g g^{-1} day^{-1} as influenced by various treatments for two growth periods (viz. seedling to 80 % flowering stage and 80% flowering to harvest) in 1994-95, 1995-96 and pooled means are presented in Table 13. Data was not statistically analysed and the drawn conclusions are based on mean numerical values. Mean RGR was 0.01910 and 0.006057 g g^{-1} day^{-1} for seedling to 80% flowering, and (-) 0.000708 and (-)0.000709 g g^{-1} day^{-1} between 80% flowering to harvest during first and second year, respectively. The corresponding pooled means were 0.012580 and (-) 0.000708 g g^{-1} day^{-1}, respectively for both the periods referred above.

Effect of sowing

Data revealed considerable effects of sowing treatments on RGR for both growing periods throughout the study. There was substaintial increase in Relative growth rate due to lateness in sowing for first growing period. Whereas for second growing period it was found to be negative, but maintained similar trend of first growing period.

Effect of P_2O_5

Application of P_2O_5 indicated favourable effects on relative growth rate throughout the study. It was minimum when no fertilizer was applied. However with every increase in P_2O_5 RGR was linearly increased for both growing periods and reached to maximum in P3, although negative values were recorded in the second growing period.

Effect of K_2O

Relative growth rate followed increaseing trend with increasing levels of K_2O for first growing period throughout the study. However,

Table 13 : Relative growth rate (RGR) g g^{-1} day^{-1} as influenced by various treatments

Treatments	1994 - 95		1995 - 96		Pooled	
	Seedling to 80% Flowering	80% Flowering to Harvest	Seedling to 80% Flowering	80% Flowering to Harvest	Seedling to 80% Flowering	80% Flowering to Harvest
Sowing time						
D1	0.01571	(-) 0.000605	0.004564	(-) 0.000549	0.010137	(-) 0.000577
D2	0.01906	(-) 0.000613	0.005258	(-) 0.000738	0.012159	(-) 0.000675
D3	0.02202	(-) 0.000678	0.006827	(-) 0.000754	0.014423	(-) 0.000716
D4	0.01977	(-) 0.001083	0.007454	(-) 0.000765	0.013612	(-) 0.000924
Levels of phosphate						
P0	0.01758	(-) 0.000652	0.004815	(-) 0.000547	0.011197	(-) 0.000599
P1	0.01897	(-) 0.000675	0.005776	(-) 0.000707	0.012373	(-) 0.000691
P2	0.01969	(-) 0.000677	0.006616	(-) 0.000769	0.013153	(-) 0.000723
P3	0.02010	(-) 0.000753	0.006913	(-) 0.000842	0.013521	(-) 0.000797
Levels of Potash						
K0	0.01853	(-) 0.000654	0.005745	(-) 0.000719	0.012137	(-) 0.000686
K1	0.01905	(-) 0.000707	0.006024	(-) 0.000700	0.012537	(-) 0.000703
K2	0.01925	(-) 0.000694	0.006303	(-) 0.000724	0.012776	(-) 0.000709
K3	0.01951	(-) 0.000705	0.006369	(-) 0.000701	0.012939	(-) 0.000703
General mean	0.01910	(-) 0.000708	0.006057	(-) 0.000709	0.012580	(-) 0.000708

for second growing period, it showed negative values with inconsistant trend. Pooled averages indicated increase in RGR upto K2 treatment and declined thereafter.

4.2.8 Number of nodules

Data on nodulation as influenced by various treatments at seedling stage and at 60, 90, 120 days during 1994-95, 1995-96 and in pooled are presented in Table 14, 15, 16 and graphically depicted in Fig. 9.

It was noted that mean number of nodules plant^{-1} increased progressively upto 90 days (165.34, 210.40 and 187.86, in first year, second year and in pooled) and subsequently dropped down. The rate of increase was maximum between 60 to 90 days (126.82, 172.7 and 149.20, in first year, second year and in pooled data, respectively) and minimum between 90 to 120 days (46.77, 48.49 and 47.56, in first year, second year and when the data was pooled, respectively) throughout the study.

Effect of sowing

Data indicated that, there was distinct effect of various sowings on root nodulation plant^{-1} during both the years. In 1994-95, number of nodules were significantly higher in first sowing followed by second. Third sowing was at par with last at seedling stage, but latteron it produced significantly more nodules than the last. In 1995-96, treatment differences were not discernible at seedling stage. However at 60th day, last treatment produced significantly more nodules than first and second. Third treatment had also significantly more nodules than first, but were similar to second and the last. At latter (90th and 120th day) stages, last followed by third treatment

Table 14 : Number of nodules plant^{-1} as influenced by various treatments at different growth intervals during 1994- 95

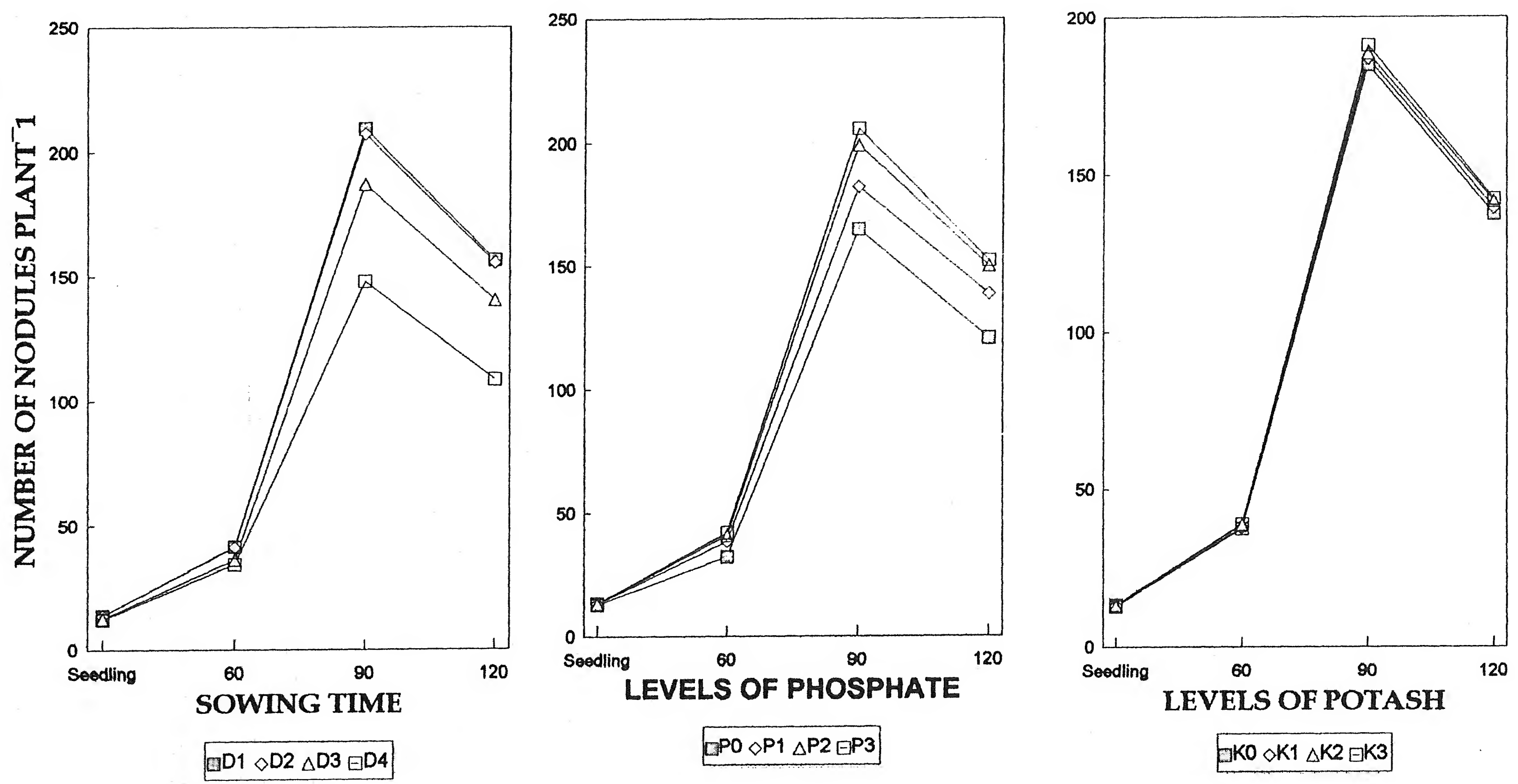
Treatments	Seedling	60	90	120
Sowing time				
D1	14.26	48.03	231.59	175.18
D2	13.60	45.41	222.08	168.70
D3	10.88	33.44	147.39	100.94
D4	10.06	27.22	60.30	29.46
S.E.(m) ±	0.31	1.01	3.14	2.72
C.D. at 5%	0.98	3.33	10.02	8.76
Levels of phosphate				
P0	11.88	33.32	149.88	99.98
P1	12.22	39.18	160.39	115.32
P2	12.31	40.26	173.09	128.08
P3	12.39	41.34	178.01	130.90
S.E.(m) ±	0.27	0.91	2.95	2.23
C.D. at 5%	N.S.	2.52	8.17	6.18
Levels of potash				
K0	11.82	38.02	162.89	116.43
K1	12.24	38.20	164.01	117.89
K2	12.33	38.80	165.32	119.84
K3	12.41	39.08	169.14	120.12
S.E.(m) ±	0.27	0.91	2.95	2.23
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	12.20	38.52	165.34	118.57

Table 15 : Number of nodules plant $^{-1}$ as influenced by various treatments at different growth intervals during 1995-96

Treatments	Seedling	60	90	120
Sowing time				
D1	13.40	34.75	186.96	138.11
D2	13.98	36.72	192.52	142.10
D3	14.22	38.69	226.72	179.93
D4	14.38	41.05	235.42	187.52
S.E.(m) ±	0.35	0.81	3.98	2.94
C.D. at 5%	N.S.	2.60	12.12	9.40
Levels of phosphate				
P0	13.64	30.72	179.62	141.63
P1	14.04	37.06	203.70	161.58
P2	14.14	41.20	224.94	171.30
P3	14.16	42.23	233.36	173.17
S.E.(m) ±	0.29	0.83	4.03	3.12
C.D. at 5%	N.S.	2.31	11.27	8.64
Levels of potash				
K0	13.75	36.62	206.94	158.49
K1	14.04	37.35	209.89	161.10
K2	14.06	38.50	211.78	163.39
K3	14.13	38.74	213.02	164.68
S.E.(m) ±	0.29	0.83	4.03	3.12
C.D.at 5%	N.S.	N.S.	N.S.	N.S.
General mean	13.99	37.80	210.40	161.91

Table 16 : Number of nodules plant^{-1} as influenced by various treatments at different growth intervals (Pooled data for the year 1994-95 & 1995-96)

Treatments	Seedling	60	90	120
Sowing time				
D1	13.83	41.39	209.27	156.64
D2	13.79	41.06	207.30	155.40
D3	12.55	36.06	187.05	140.43
D4	12.22	34.13	147.86	108.49
S.E.(m) ±	0.23	0.65	12.53	2.01
C.D. at 5%	0.71	1.90	7.58	6.01
Levels of phosphate				
P0	12.76	32.02	164.75	120.55
P1	13.13	38.12	182.04	138.44
P2	13.22	40.73	199.01	159.69
P3	13.27	41.78	205.68	152.03
S.E.(m) ±	0.20	0.61	2.50	1.92
C.D. at 5%	N.S.	1.73	6.90	5.30
Levels of potash				
K0	12.78	37.32	184.92	137.46
K1	13.14	37.77	186.93	139.49
K2	13.19	38.65	188.55	141.61
K3	13.24	38.91	191.08	142.40
S.E.(m) ±	0.20	0.61	2.50	1.92
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	13.09	38.16	187.86	140.30



60,90 & 120 INDICATES DAYS

FIG.9. NUMBER OF NODULES PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS AT DIFFERENT GROWTH INTERVALS.

which did not differ with each other, beared significantly more nodules than first and second sowing. However, differences within first and second sowings were non significant during both the years. Thus, in 1994-95, nodule production decreased due to late sowings and were maximum in early sowings at first (231.59) followed by second date (222.08) amongst all. On the contrary it was increased in the late sown treatments and were higher in last (235.42 and third (226.72) in 1995-96. Pooled data indicated significant increase in nodule number due to early sowings throughout growth intervals. First followed by second sowing, found to be superior than all the tretments at all growth intervals and produced maximum nodules plant^{-1} (209.27 and 207.30 respectively) but remained at par with each other. Third sowing was also superior to ~~than~~ the last at all growth intervals except at seedling stage, when it was at par with last sowing.

Effect of P_2O_5

Data pertaining to the effect of P_2O_5 on nodulation for individual year and also on pooled basis indicated that, nodules plant^{-1} were enhanced significantly after seedling stage only. During first year, P1 to P3 produced significantly more nodules plant^{-1} than P0 at 60th day but did not differ signicantly among themselves. At 90th and 120th day during first year and from 60th day onwards during second year each incremental dose of P_2O_5 registered significant increase in nodule number over lower doses upto P2. Further increase in P_2O_5 (P3) was not significant over P2, but produced significantly maximum nodules plant^{-1} than rest of the treatments. Pooled analysis also indicated similar trend.

Effect of K_2O

Application of K_2O did not produce significant influence on nodulation during both the years. Pooled analysis also confirms th same effects.

Interaction

Interaction of various factors had no considerable influence on nodulation throughout the investigation.

4.2.9 Nodule dry matter

Data related to nodule dry matter $plant^{-1}$ are presented in Table 17, 18 and 19.

The mean nodule dry matter $plant^{-1}$ found to be linearly increased upto 90^{th} day (0.025523, 0.028618 and 0.027070 g, in first year, second year and in pooled data, respectively) and decreased thereafter throughout the study. The rate of increase was maximum between 60 to 90 days (0.019884, 0.024416 and 0.022151 g, in first year, second year and in pooled data, respectively) and found to be decreased subsequently (0.002550, 0.001209 and 0.001842 g, in first year, second year and in pooled data, respectively).

Effect of sowing

Sowing treatments showed significant variation in nodule dry matter $plant^{-1}$ throughout all growth intervals, except at seedling stage during second year. In 1994-95, first sowing followed by second had significantly higher nodule dry matter than rest of the sowings, but did not differ with each other in their performance at all stages of observations. Third and last sowing, though did not vary significantly among themselves at seedling

Table 17 : Nodule dry matter plant $^{-1}$ (g) as influenced by various treatments at different growth intervals during 1994-95

Treatments	Seedling	60	90	120
Sowing time				
D1	0.001353	0.006746	0.033095	0.031238
D2	0.001314	0.006460	0.031687	0.030536
D3	0.001044	0.005015	0.023223	0.021952
D4	0.001027	0.004336	0.014088	0.008466
S.E.(m) ±	0.000025	0.000105	0.000523	0.000454
C.D. at 5%	0.000080	0.000340	0.001670	0.001452
Levels of phosphate				
P0	0.001163	0.005052	0.022480	0.019545
P1	0.001183	0.005746	0.024910	0.022504
P2	0.001190	0.005843	0.026799	0.024855
P3	0.001202	0.005916	0.027904	0.025288
S.E. (m) ±	0.000021	0.000092	0.000442	0.000347
C.D. at 5%	N.S.	0.000250	0.001224	0.000962
Levels of potash				
K0	0.001164	0.005522	0.025198	0.022730
K1	0.001180	0.005648	0.025433	0.022893
K2	0.001193	0.005686	0.025270	0.023216
K3	0.001201	0.005701	0.025755	0.023353
S.E. (m) ±	0.000021	0.000092	0.000442	0.000347
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	0.001184	0.005639	0.025523	0.023048

Table 18 : Nodule dry matter plant $^{-1}$ (g) as influenced by various treatments at different growth intervals during 1995-96

Treatments	Seedling	60	90	120
Sowing time				
D1	0.001019	0.003959	0.024815	0.023812
D2	0.001028	0.004129	0.025688	0.024146
D3	0.001058	0.004276	0.031274	0.030188
D4	0.001071	0.004444	0.032696	0.031492
S.E. (m) ±	0.000020	0.000076	0.000540	0.000482
C.D. at 5%	N.S.	0.000244	0.001726	0.001541
Levels of phosphate				
P0	0.001030	0.003825	0.026306	0.024414
P1	0.001040	0.004106	0.028022	0.026918
P2	0.001048	0.004398	0.029676	0.028836
P3	0.001058	0.004479	0.030469	0.029470
S.E. (m) ±	0.000017	0.000065	0.000494	0.000418
C.D. at 5 %	N.S.	0.000180	0.001368	0.001158
Levels of potash				
K0	0.001026	0.004147	0.027886	0.027041
K1	0.001044	0.004175	0.028578	0.027328
K2	0.001050	0.004229	0.028917	0.027539
K3	0.001056	0.004257	0.029092	0.027730
S.E. (m) ±	0.000017	0.000065	0.000494	0.000418
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	0.001044	0.028618	0.028618	0.27439

Table 19 : Nodule dry matter plant $^{-1}$ (g) as influenced by various treatments at different growth intervals (Pooled data for the year 1994-95 & 1995-96)

Treatments	Seedling	60	90	120
Sowing time				
D1	0.001186	0.005352	0.028955	0.027525
D2	0.001171	0.005294	0.028687	0.027341
D3	0.001051	0.004645	0.027248	0.026070
D4	0.001049	0.004385	0.023392	0.019979
S.E. (m) ±	0.000016	0.000065	0.000376	0.000332
C.D. at 5%	0.000047	0.000194	0.001128	0.000993
Levels of phosphate				
P0	0.001096	0.004438	0.024393	0.021979
P1	0.001111	0.004926	0.026466	0.024711
P2	0.001119	0.005120	0.028237	0.026845
P3	0.001130	0.005197	0.029186	0.027379
S.E. (m) ±	0.000013	0.000056	0.000331	0.000271
C.D. at 5 %	N.S.	0.000157	0.000918	0.000752
Levels of potash				
K0	0.001095	0.004834	0.026542	0.024885
K1	0.001112	0.004911	0.027005	0.025110
K2	0.001121	0.004957	0.027312	0.025377
K3	0.001128	0.004979	0.027423	0.025541
S.E. (m) ±	0.000013	0.000056	0.000331	0.000271
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	0.001019	0.004919	0.027070	0.25228

stage, but subsequently produced higher nodule dry matter than the last sowing. From this it can be inferred that delay in sowing showed significant reduction in nodule dry matter plant^{-1} during this year. In 1995-96, significant performance of various treatments was recorded from 60th day and nodule dry matter plant^{-1} significantly increased in delayed sowings. At this age, last sowing had significantly higher nodule dry matter than first, but was at par with third and second sowings. Similarly, first and second sowing was also at par with each other at this age. Latter on (90th and 120th day) both latter sowings, last followed by third, proved significantly superior over both earlier sowings, first and second, but did not differ significantly with each other (last and third). Similarly, first and second also did not differ within them at this age. At highest stage of nodulation (90th day) there was significantly maximum nodule dry matter in first (0.033095 g) followed by second (0.031687 g) sowing in first year. Contrary to this, during second year, it was higher in last (0.032696 g) followed by third (0.031274 g) sowing. Pooled data showed almost superiority of first followed by second over rest of the sowings at all growth intervals and produced maximum nodule dry matter plant^{-1} (0.028955 and 0.028687 g respectively) at 90th day of growth. Third sowing was also significantly superior over the last at all stages except at seedling stage when, it was at par with this treatments (last).

Effect of P_2O_5

Data did not indicate significant influence of P_2O_5 on nodule dry matter plant^{-1} at seedling stage in 1994-95, 1995-96 and also when pooled. Treatment P3 followed by P2 and P1 produced significantly higher nodule dry matter than P0, but did not differ significantly among themselves at the

age of 60th day during first year. But at 90th and 120th day during first year and from 60th day onwards during second year and when the data was pooled, each successive increase in P_2O_5 level proved to be significantly superior over lower level upto P2. Further increase in P_2O_5 did not bring significant increase in nodule dry matter over P2. At highest stage of dry matter, P3 (0.029186 g) followed by P2 (0.02823 g) produced maximum nodule dry matter amongst all treatments.

Effect of K_2O

Graded levels of K_2O, from K0 to K3 had no significant influence on nodule dry matter plant^{-1} in all the observations during the study.

Interaction

Nodule dry matter plant^{-1} was not affected by any of the interactions throughout the study.

4.2.10 Root dry matter

Data on root dry matter plant^{-1} are presented in Table 20, 21 and 22.

Mean root dry matter plant^{-1} found to be linearly increased upto 120 days throughout the study, (2.408, 1.201 and 1.804 g, in first year, second year and in pooled respectively). Highest rate of increase was noted in between 60 to 90 days (1.570, 0.519 and 1.045 g, in first year, second year and in pooled data). The rate of increase was decreased after 90th day throughout the study (0.114, 0.089 and 0.095 g, in first year, second year as well as in pooled data respectively).

Table 20 : Root dry matter plant^{-1} (g) as influenced by various treatments at different growth intervals during 1994-95

Treatments	Seedling	60	90	120
Sowing time				
D1	0.030	0.948	3.026	3.135
D2	0.029	0.916	2.890	2.986
D3	0.025	0.638	2.096	2.212
D4	0.023	0.394	1.166	1.299
S.E. (m) ±	0.0010	0.014	0.040	0.054
C.D. at 5%	0.0032	0.045	0.150	0.171
Levels of phosphate				
P0	0.026	0.674	1.984	2.116
P1	0.027	0.730	2.259	2.329
P2	0.027	0.738	2.441	2.546
P3	0.027	0.754	2.494	2.641
S.E. (m) ±	0.00095	0.011	0.040	0.042
C.D. at 5%	N.S.	0.030	0.110	0.115
Levels of potash				
K0	0.026	0.714	2.251	2.363
K1	0.027	0.720	2.283	2.407
K2	0.027	0.728	2.319	2.420
K3	0.027	0.734	2.325	2.422
S.E. (m) ±	0.00095	0.011	0.040	0.042
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	0.026	0.724	2.294	2.408

Table 21 : Root dry matter plant^{-1} (g) as influenced by various treatments at different growth intervals during 1995-96

Treatments	Seedling	60	90	120
Sowing time				
D1	0.020	0.521	0.882	0.955
D2	0.021	0.541	0.944	1.024
D3	0.022	0.642	1.286	1.385
D4	0.022	0.670	1.336	1.443
S.E.(m) ±	0.0007	0.012	0.021	0.026
C.D. at 5%	N.S.	0.038	0.068	0.084
Levels of phosphate				
P0	0.020	0.548	0.889	1.010
P1	0.021	0.594	1.076	1.123
P2	0.022	0.612	1.227	1.312
P3	0.022	0.620	1.256	1.362
S.E. (m) ±	0.00069	0.010	0.019	0.023
C.D. at 5%	N.S.	0.028	0.052	0.064
Levels of potash				
K0	0.021	0.583	1.090	1.180
K1	0.021	0.590	1.102	1.194
K2	0.021	0.599	1.122	1.212
K3	0.022	0.602	1.134	1.221
S.E. (m) ±	0.00069	0.010	0.019	0.020
C.D. at 5%	N.S.	N.S	N.S.	N.S.
General mean	0.021	0.593	1.112	1.201

Table 22 : Root dry matter plant^{-1} (g) as influenced by various treatments at different growth intervals (Pooled data for the year 1994-95 & 1995-96)

Treatments	Seedling	60	90	120
Sowing time				
D1	0.025	0.734	1.954	2.045
D2	0.025	0.728	1.917	2.005
D3	0.023	0.640	1.691	1.798
D4	0.022	0.532	1.251	1.371
S.E. (m) ±	0.00061	0.00092	0.026	0.030
C.D. at 5%	0.0018	0.027	0.075	0.088
Levels of phosphate				
P0	0.023	0.611	1.436	1.563
P1	0.023	0.662	1.667	1.726
P2	0.024	0.675	1.834	1.929
P3	0.024	0.687	1.875	2.001
S.E. (m) ±	0.00058	0.0081	0.023	0.026
C.D. at 5%	N.S.	0.022	0.064	0.072
Levels of potash				
K0	0.023	0.648	1.670	1.771
K1	0.024	0.655	1.692	1.800
K2	0.024	0.663	1.720	1.816
K3	0.024	0.668	1.729	1.831
S.E. (m) ±	0.00058	0.0081	0.023	0.026
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
General mean	0.023	0.658	1.703	1.804

Effect of sowing

As observed from the data, root dry matter plant^{-1} indicated reverse trend of results during the two respective years. In 1994-95, it increased due to early sowings and was significantly highest in first followed by second at all growth intervals than rest of the treatments. Subsequent delay as in the third, root dry matter decreased significantly, but was significantly higher than last sowing, except at seedling stage only. In 1994-95, treatment differences were not conspicuous at seedling stage. But with march of time there was significant variation within the treatments. Last sowig followed by third registered significantly higher root dry matter amongst all treatments. However, both these treatments were similar in effects with each other. Similarly, first and second sowing was also similar in effect with each other during first as well as second year. Thus, at highest stage of root development first sowing (3.135 g) followed by second (2.986g) produced maximum root dry matter in 1994-95. Contrary to this, it was significantly maximum in last (1.443 g) floowed by third (1.385 g) treatment during second year. Perusal of pooled data indicated significant performance of both earliest sowings (first followed by second) over third and last throughout growth intervals and produced maximum root dry matter (2.045 and 2.005 g) at 120th day amongst all treatments. Second sowing was similar to third at seedling stage, but latteron proved significantly superior over this treatment and also over the last treatment throughout growth interval. Similarly, third sowing was at par with last at seedling stage, but proved better than last at rest of the growth intervals. Early two sowings (first and second) were almost similar in effects with each other.

Effect of P_2O_5

Various levels of P_2O_5 significantly increased root dry matter ~~matter~~ plant^{-1} throughout the study. At seedling stage, it remained unaffected due to P_2O_5. In 1994-95 and 1995-96, from 60th day onward P_2O_5 application from P1 to P3 proved significantly superior over unfertilized treatment. However, all the treatments from P1 to P3 were at par to one another. From 90th day onwards effect of P_2O_5 was more consistant and each higher dose increased root dry matter significantly over each lower dose upto P2 only. Further increase in P_2O_5 level to P3 failed to increase root dry matter significantly over P2, but was significantly superior over P0 and P1. Pooled data followed similar trend of effects except on 60th day when P1 had higer root dry matter than control treatment, and P3 had over P1. At highest stage of root development, there was maximum root dry matter in P3 (2.001 g) followed by P2 (1.929 g) which were at par.

Effect of K_2O

Increasing levels of K_2O did not show considerable effect on root dry matter plant^{-1} neither in individual year nor when the data was pooled.

Interaction

Effect of various treatment conbinations were non significant on root dry matter plant^{-1} in 1994-95, 1995-96 and when the data was analysed on pooled basis.

4.2.11 Floral initiation

Data presented in Table 23 revealed that, mean number of days required for flower initiation were 46.65 in 1994-95 as against 49.86

Table 23 : Days to flower initiation as influencd by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	51.79	49.32	50.55
D2	47.89	50.18	49.03
D3	44.37	50.06	47.21
D4	42.56	49.90	46.23
S.E. (m) ±	0.63	0.57	0.42
C.D. at 5%	2.01	N.S.	1.25
Levels of phosphate			
P0	48.28	52.46	50.37
P1	46.23	49.18	47.70
P2	46.11	48.98	47.54
P3	45.99	48.84	47.41
S.E. (m) ±	0.57	0.54	0.39
C.D. at 5%	1.59	1.52	1.08
Levels of potash			
K0	46.79	50.10	48.44
K1	46.78	50.00	48.39
K2	46.70	49.70	48.20
K3	46.34	49.65	47.99
S.E. (m) ±	0.57	0.54	0.39
C.D. at 5%	N.S.	N.S.	N.S.
General mean	46.65	49.86	48.25

days in 1995-96. The corresponding value in pooled data was 48.25 days.

Effect of sowing

Data indicated substantial effect of sowing treatments on floral initiation throughout the study. In 1994-95, with every delay in sowing there was significant reduction in the period of floral initiation. First sowing took significantly more period (51.79 days) followed by second (47.89 days), third (44.37 days) and fourth (42.56 days). The first being superior over the second, and the second over last two, which were at par. During second year, all the sowings did not vary significantly with one another. The pooled analysis showed the trend of first year results.

Effect of P_2O_5

Flower initiaiton was significantly affected due to P_2O_5 fertilization throughout the study. In all the treatments from P1 to P3, flower initiation was significantly hastened than P0 (50.37 days). But differences amongst P1 to P3 were non significant.

Effect of K_2O

Various levels of K_2O did not reveal noticeable influence on floral initiation during 1994-95, 1995-96 and also when the data was pooled.

Interaction

Interaciton effects regarding floral initiantion were not found signifiant throughout the study.

4.2.12 Maturity

Data on crop maturity are presented in Table 24.

Mean number of days to attain maturity were observed

Table 24 : Days to maturity as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	187.59	200.17	193.88
D2	173.01	200.10	186.55
D3	157.95	200.11	179.03
D4	142.62	200.00	171.31
S.E. (m) ±	2.30	1.01	1.25
C.D. at 5%	7.37	N.S.	3.77
Levels of phosphate			
P0	166.92	201.09	184.00
P1	164.87	200.32	182.59
P2	164.81	199.76	182.28
P3	164.57	199.23	181.90
S.E. (m) ±	2.08	1.31	1.23
C.D. at 5%	N.S.	N.S.	N.S.
Levels of potash			
K0	165.50	200.26	182.88
K1	165.35	200.09	182.72
K2	165.17	200.04	182.60
K3	165.15	200.01	182.58
S.E. (m) ±	2.08	1.31	1.23
C.D. at 5%	N.S.	N.S.	N.S.
General mean	165.29	200.09	182.69

to be 165.29, 200.09 and 182.69, during first year, second year and when the data was analysed on pooled basis. This indicated that, maturity period was delayed in second year as compared to that in the first year of study.

Effect of sowing

Sowing treatments significantly influenced maturity of *S. hamata* throughout the study except during second year. In 1994-95, each early sowing consumed more period to reach to maturity than each subsequent delayed sowing. First sowing took significantly longer period (187.59 days) to attain maturity amongst all. Maturity in second sowing was hastened than first (173.01 days) but was significantly delayed than last two sowings. The period for maturity attained by third sowing (157.95 days) was also significantly more than last (142.62 days). Thus, with every delay in sowing maturity period was significantly reduced. In 1995-96, there was no significant variation in crop maturity due to various sowings. The trend of first year was reflected when the data was pooled wherein days to reach maturity were significantly more in first (193.88) followed by second (186.55), third (179.03) and last (171.31) sowing.

Effect of P_2O_5

Data did not indicate significant influence of P_2O_5 on crop maturity at all levels of its application throughout the investigation.

Effect of K_2O

Graded levels of K_2O from K0 to K3 did not show conspicuous effect on crop maturity neither in individual year nor when the data was pooled.

Interaction

Effect of interactions were not found signficant throughout the study.

4.3 Post-harvest studies

Direct and indirect yield contributory characters, such as number of balls plant^{-1}, weight of balls plant^{-1}, number of seeds balls^{-1}, weight of seeds ball^{-1} were recorded in 1994-95 and 1995-96. The data of two respective years ~~was~~ were pooled and findings are presented hereunder.

4.3.1 Number of balls

The number of balls plant^{-1} are presented in Table 25 and graphically shown in fig. 10.

Mean number of balls plant^{-1} were 324.62 in 1994.95 as against 56.50 in the year 1995-96. Pooled data indicated 190.55 balls plant^{-1}. It was noted that, number of balls plant^{-1} were nearly six times more in first year compared to those in the subsequent year of study.

Effect of sowing

Data indicated significant influence of sowing treatments on number of balls plant^{-1} during both the years. In 1994-95, number of balls decreased due to delay in sowing and were significantly lowest in the last sowing, as against highest in the same teratment (60.15) in 1995-96, amongst all. Similarly, first (373.20) followed by second (360.49) sowing produced significantly more balls plant^{-1} in 1994-95 as against lowest in both these treatments in 1995-96 amongst all. Third sowing was significantly superior over last in 1994-95, but at the same time was at par with this treatment in 1995-96. First and second sowings were also at par with each other during

both the years. Pooled data almost indicatd significantly more balls at first (212.57) followed by second (207.40) sowing which were equally better over rest of the treatments. Third sowing was also superior than last.

Effect of P_2O_5

Graded levels of P_2O_5 favourably influenced number of balls plant^{-1} in 1994-95,1995-96 and when the data was polled. Unfertilized treatment was most inferior amongst all. When first increament (P1) was made, number of balls plant^{-1} found to be significantly increased over P0 treatment. At second increament of P_2O_5 (P2) also the number of balls plant^{-1} (211.11) were significantly increased over P0 and P1 treatments. But the third increament (P3) of P_2O_5 failed to increase the number of balls (205.27) further.

Effect of K_2O

Influence of K_2O on number of balls plant^{-1} was non significant throughout the study.

Interaction

None of the interactions affected number of balls plant^{-1} significantly either in individual year or on pooled basis.

4.3.2 Weight of balls

Data regarding weight of balls plant^{-1} are presented in Table 25 and graphically shown in Fig.11.

Mean weight of balls plant^{-1} was observed to be 9.132 g in first year and 1.369 g in the second year respectively. Corresponding value in pooled data was 5.243 g plant^{-1}.

Table 25 : Number of balls plant $^{-1}$ and weight of balls plant $^{-1}$ (g) as influencd by various treatments

Treatments	Number of balls			Weight of balls		
	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled
Sowing time						
D1	373.20	51.95	212.57	10.314	1.212	5.763
D2	360.49	54.32	207.40	9.880	1.272	5.576
D3	301.84	59.58	180.71	8.846	1.474	5.160
D4	262.97	60.15	161.56	7.491	1.518	4.504
S.E. (m) ±	6.26	0.95	3.16	0.168	0.024	0.085
C.D. at 5%	19.96	3.04	9.50	0.536	0.077	0.254
Levels of phosphate						
P0	280.60	44.80	162.70	7.673	1.121	4.397
P1	310.93	55.41	183.17	9.115	1.346	5.230
P2	358.69	63.53	211.11	9.963	1.527	5.745
P3	348.28	62.26	205.27	9.780	1.482	5.631
S.E. (m) ±	5.55	1.14	2.83	0.151	0.023	0.076
C.D. at 5%	15.38	3.16	7.83	0.418	0.064	0.211
Levels of potash						
K0	319.49	54.52	187.00	8.954	1.339	5.146
K1	323.43	56.95	190.14	9.143	1.363	5.253
K2	326.75	57.12	191.93	9.200	1.380	5.290
K3	328.84	57.41	193.12	9.234	1.394	5.314
S.E. (m) ±	5.55	1.14	2.83	0.151	0.023	0.078
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	324.62	56.50	190.55	9.132	1.369	5.243

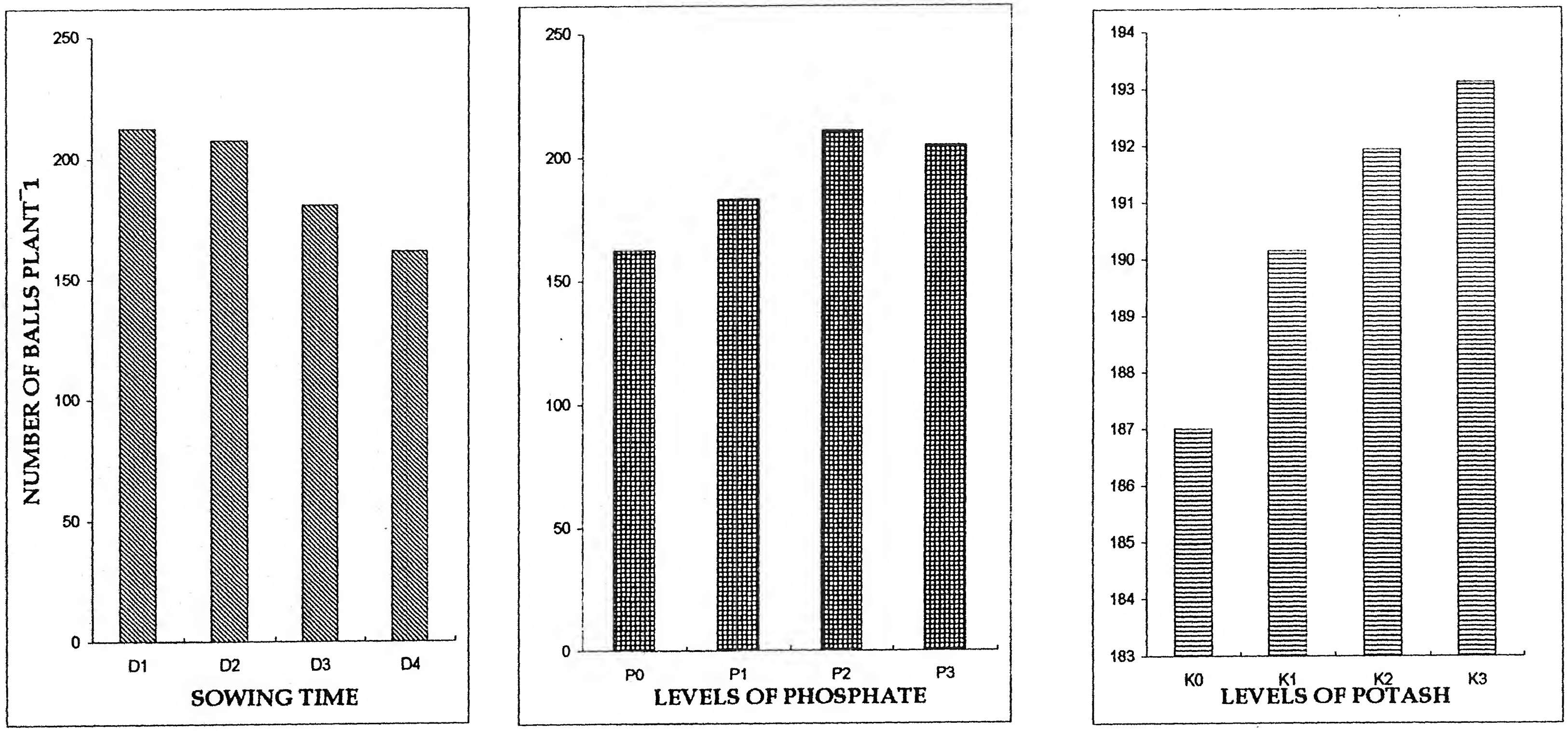


FIG. 10: NUMBER OF BALLS PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS

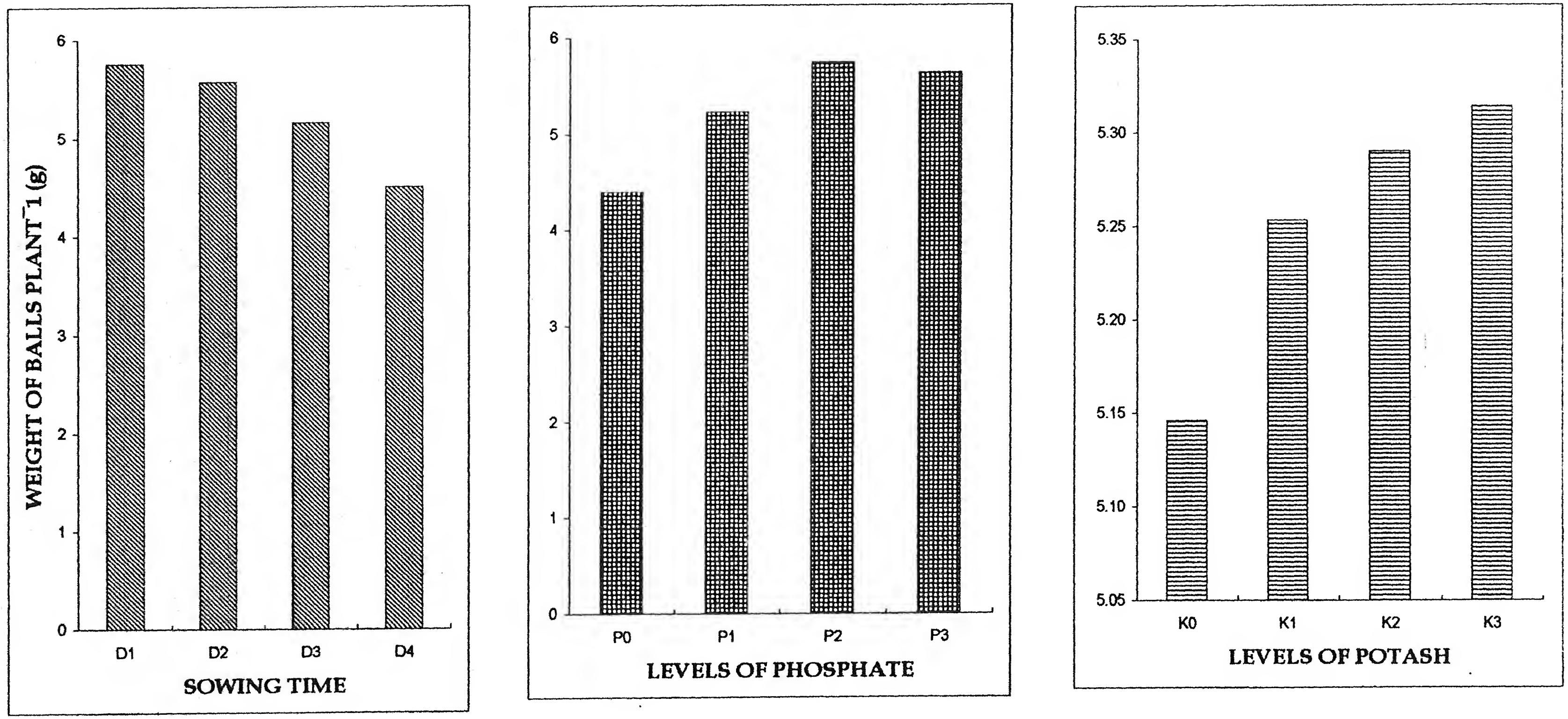


FIG. 1 1: WEIGHT OF BALLS PER PLANT (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS.

Effect of sowing

The weight of balls plant^{-1} was signigicantly influenced due to sowing treatments throughout the experimentation. Delay in sowing caused significant reduction in weight of balls plant^{-1} in 1994-95. First (10.314 g) followed by second (9.880 g) sowing, which proved to be similar in effects, recorded significantly higher weight of balls than rest of the treatments. Similarly, third sowing also showed significantly higher weight of balls than the last. In 1995-96, weight of balls increased in the delayed treatments and last (1.518 g) followed by third (1.474 g) sowing exhibited significant increase in ball's weight than first and second. However, differences amongst last and third as well as first and second sowings were non significant. Pooled data revealed decrease in ball's weight with delay in sowing. Last sowing had significantly lowest weight amongst all treatments. In third sowing, weight of balls was improved over the last. However, earliest sowings at first (5.763 g) followed by second (5.576 g) date recorded significantly highest weight of balls amongst all sowings, but remained at par with each other.

Effect of P_2O_5

Graded levels of P_2O_5 exhibited significant influence on weight of balls plant^{-1} in 1994-95,1995-96 and in pooled data also. Treatment P2 (5.745 g) recorded significantly higher weight of balls than rest of the treatments, except P3, which were at par with each other. Similarly, the weight of balls recorded at P1 was also significantly more than that observed in the unfertilized treatment. Data further revealed that, weight of balls could not increase beyond P2 treatment.

Effect of K_2O

Weight of balls Plant^{-1} was not found affected by various levels of K_2O in 1994-95,1995-96 and when the data was pooled.

Interaction

Interaction effects were non significant throughout the experimentation.

4.3.3 Number of seeds

Data related to number of seeds ball^{-1} are presented in Table 26.

On an average, there were 8.30, 3.64 and 5.97 seed ball^{-1} in 1994-95, 1995-96 and when the data was pooled, respectively.

Effect of sowing

Sowing treatments did not show significant influence on number of seeds ball^{-1}, although ~~were~~ decreased due to delay in sowing during first year and increased in delayed treatments during second year. Pooled data indicated more or less similar trend.

Effect of P_2O_5

Data indicated increasing trend with increasing levels of P_2O_5 throughout the study, but differences amongst treatments did not reach the level of significance.

Effect of K_2O

Graded levels of K_2O had no significant influence on number of seeds ball^{-1} during both the years as well as when the data was pooled.

Interaction

There was no significant influence of various treatment combinations on number of seeds $ball^{-1}$.

4.3.4 weight of seeds

Data on weight of seeds $ball^{-1}$ are presented in Table 26. Average weight of seeds $ball^{-1}$ was found to be 0.01814 g in 1994-95, 0.00613 g in 1995-96 and 0.01213 g, in pooled data, respectively.

Effect of sowing

In 1994-95, weight of seeds $ball^{-1}$ was found to be significantly increased due to early sowing at first (0.01902 g) date over third and last. Sowing at second date (0.01843 g) also recorded more weight of seed than last, but was at par with first sowing on one hand, and with third sowing on the other. Third and last sowings were almost at par with each other. In 1995-96, sowing treatments had no effect on weight of seeds $ball^{-1}$ Pooled data indicated almost similar trend of first year, wherein first (0.01250 g) and second (0.01228 g) sowings were found to be superior over last, but at par with each other. Similarly, third sowing with second, as well as with last was also at par.

Effect of P_2O_5

Application of P_2O_5 did not increase seed weight $ball^{-1}$ significantly in 1994-95, 1995-96. Similar results were noticed when the data was pooled.

Effect of K_2O

Influence of K_2O on weight of seeds $ball^{-1}$ was non significant throughout the study.

Table 26 : Number of seeds ball^{-1} and weight of seeds ball^{-1} (g) as influencd by various treatments

Treatments	Number of seeds ball^{-1}			Weight of seeds ball^{-1}		
	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled
Sowing time						
D1	8.47	3.59	6.03	0.01902	0.00599	0.01250
D2	8.42	3.62	6.02	0.01843	0.00614	0.01228
D3	8.16	3.67	5.91	0.01781	0.00617	0.01199
D4	8.15	3.70	5.92	0.01732	0.00624	0.01178
S.E. (m) ±	0.11	0.04	0.058	0.00022	0.000074	0.00011
C.D. at 5%	N.S.	N.S.	N.S.	0.00070	N.S.	0.00035
Levels of phosphate						
P0	8.21	3.61	5.91	0.01801	0.00603	0.01202
P1	8.28	3.65	5.96	0.01811	0.00612	0.01211
P2	8.32	3.66	5.99	0.01820	0.00618	0.01219
P3	8.39	3.68	6.03	0.01826	0.00621	0.00010
S.E. (m) ±	0.09	0.035	0.048	0.00019	0.000065	0.00010
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Levels of potash						
K0	8.23	3.61	5.92	0.01805	0.00606	0.01205
K1	8.27	3.64	5.95	0.01815	0.00611	0.01213
K2	8.33	3.66	5.99	0.01818	0.00617	0.01217
K3	8.37	3.67	6.02	0.01820	0.00620	0.01229
S.E. (m) ±	0.09	0.035	0.048	0.00019	0.000065	0.00010
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	8.30	3.64	5.97	0.01814	0.00613	0.01213

Interaction

None of the interactions indicated significant influence on weight of seeds ball^{-1} either in individual year or when the data was examined on pooled basis.

4.3.5 Seed yield

Data related to seed yield plant^{-1} are presented in Table 27.

Mean seed yield plant^{-1} was observed to be 5.700 g in first year, 0.347 g in second year and 3.023 g on pooled basis. It was noted that, first year's crop produced more seed plant^{-1} compared to that observed in the second year.

Effect of sowing

As observed from the data, sowing treatments had distinct effects on seed yield plant^{-1} throughout the study. In 1994-95, seed yield increased due to early sowings and was significantly maximum in first (6.430 g) followed by second date (6.152 g) amongst all treatments. But both these sowings were at par with each other. Delay in sowing caused significant reduction in seed yield as observed in the third and last sowings. On the contrary in 1995-96, the seed yield plant^{-1} found to be significantly increased in delayed treatments which was highest in last (0.387 g) followed by third (0.364 g) sowing compared to first and second. However, treatment differences within last and third as well as first and second were non significant. Thus, there was reduction in seed yield plant^{-1} to the extent of 25.66% in last sowing, over first in the initial year. At the same time there was increase in the seed yield in the same treatment (last) to the extent of 22% over

Table 27 : Seed yield plant^{-1} (g) as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	6.430	0.317	3.373
D2	6.152	0.320	3.236
D3	5.438	0.364	2.901
D4	4.780	0.387	2.583
S.E. (m) ±	0.144	0.0085	0.072
C.D. at 5%	0.461	0.027	0.214
Levels of phosphate			
P0	4.960	0.279	2.619
P1	5.580	0.347	2.963
P2	6.195	0.386	3.290
P3	6.065	0.376	3.220
S.E. (m) ±	0.117	0.0075	0.058
C.D. at 5%	0.325	0.021	0.162
Levels of potash			
K0	5.524	0.338	2.930
K1	5.706	0.346	3.031
K2	5.768	0.349	3.053
K3	5.802	0.355	3.078
S.E. (m) ±	0.117	0.021	0.058
C.D. at 5%	N.S.	N.S.	N.S.
General mean	5.700	0.347	3.023

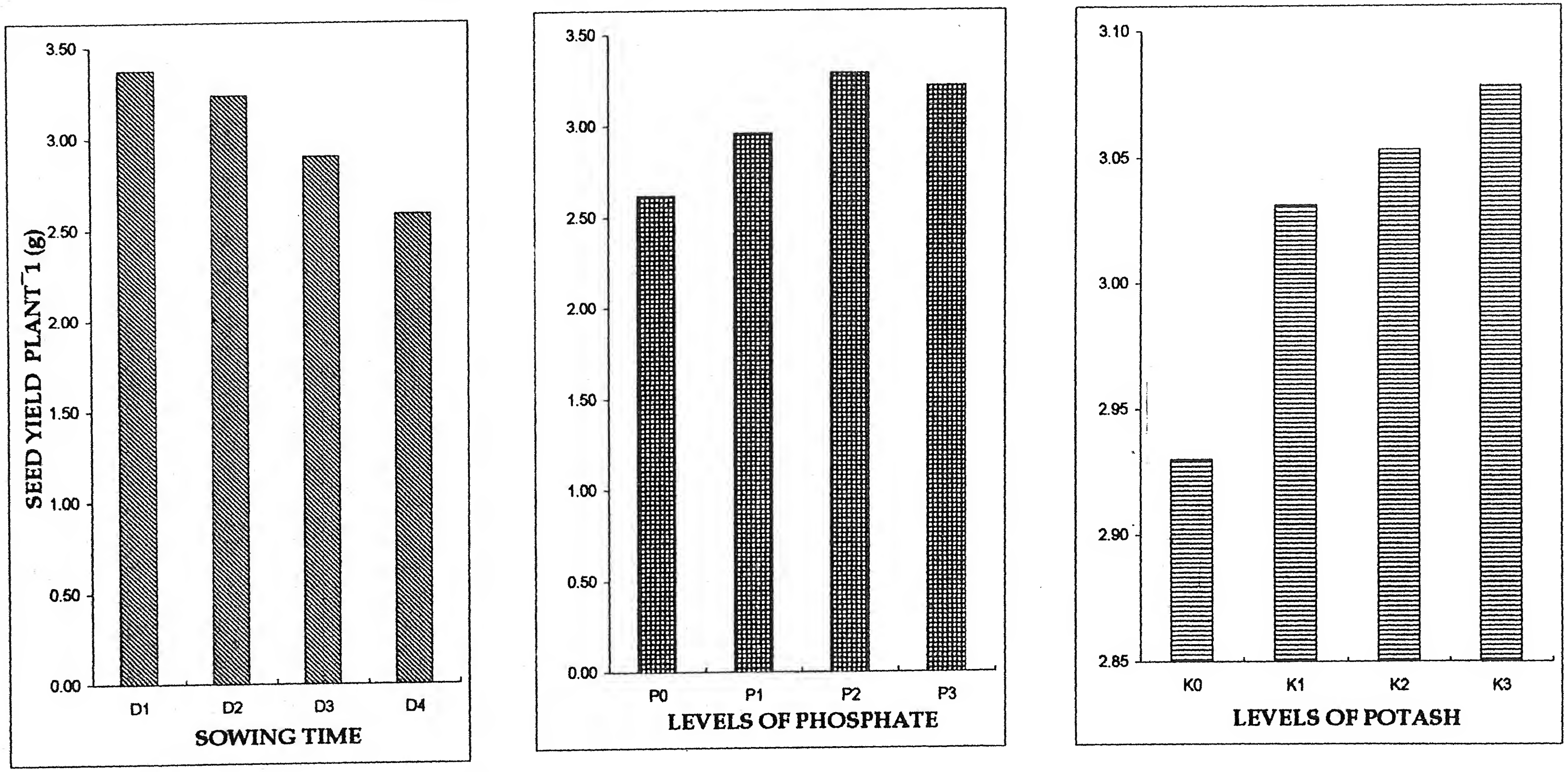


FIG. 12: SEED YIELD PER PLANT(POOLED) AS INFLUENCED BY VARIOUS TREATMENTS.

first sowing in the subsequent year of study.

Effect of P_2O_5

Application of P_2O_5 favourably increased seed yield plant^{-1} in 1994-95 and 1995-96. With each successive increase in P_2O_5 level, there was significant increase in the seed yield over preceeding level upto P2 treatment (6.195 and 0.386 g). However, subsequent increase in P_2O_5 at the rate of P3(6.065 and 0.376 g) did not increase seed yield further.

Effect of K_2O

Graded levels of K_2O had no conspicuous effect on the seed yield plant^{-1} throughout the study.

Interaction

Sowing time x P_2O_5 levels

The interaction effect between sowing time xP_2O_5 was found to be significant during both the years. Data presented in Table 27(a) revealed that, during first year, first sowing in combinaiton with P2 followed by P3 gave maximum seed yield over combination of unfertilized treatment and P1 also, but both these combinations were at par with each other. Similarly, combination of P0 and P1 were also at par at this date. In second sowing, combination of P2 followed by P1 and P3 were consistantly superior over P0 combination, but they did not differ with one another. At third sowing, seed yield increased significantly in combination with P3 over rest of the treatment combinations. However, at last sowing, P2 produced maximum seed followed by P3 and P1 over P0, but all these combinations were similar to one another.

Table 27 (a) : **Seed yield plant^{-1} (g) as influenced by sowing time x levels of phosphate during 1994-95 and 1995-96**

D/P	P0	P1	P2	P3	Mean
D1	5.405	5.952	7.381	6.983	6.430
	(0.251)	(0.349)	(0.327)	(0.342)	(0.317)
D2	5.280	6.410	6.702	6.216	6.152
	(0.232)	(0.303)	(0.388)	(0.357)	(0.320)
D3	5.067	5.227	5.380	6.079	5.438
	(0.289)	(0.381)	(0.385)	(0.401)	(0.364)
D4	4.088	4.733	5.318	4.982	4.780
	(0.345)	(0.357)	(0.444)	(0.405)	(0.387)
Mean	4.960	5.580	6.195	6.067	
	(0.279)	(0.347)	(0.386)	(0.376)	

	D x P
S.E. (m) ±	0.234 (0.015)
C.D. at 5%	0.647 (0.041)

(Figures in parenthesis refers to the year 1995 - 96)

During second year seed yield plant^{-1} was significantly higher in first sowing in combinaiton with P1 followed by P3 and P2, over control combinations, but all these combinations were at par with one another. At second sowing, each successive increase upto combination of P2 proved to be significantly superior over rest of the combinations. Further increase was non significant over P2. At third sowing, in all P_2O_5 combinations seed yield was significantly higher than control combination, but they did not differ among themselves. At last sowing also, each successive increase upto P2 combination produced significantly more seed plant^{-1} over preceeding combinations.

Briefly, the combination of DIP2 (7.381 g) gave significantly highest seed yield plant^{-1} compared to all treatment combinations in first year. However, in second year it was higher at D4P2 (0.444 g) amongst all combinations

Pooled effects

Mean seed yield plant^{-1} was found to be 3.023 g when the data of 1994-95 and 1995-96 ~~was~~ were pooled. The same is presented in Table 27 and graphically depicted in Fig. 12.

Effect of sowing

Pooled data indicated significant decrease in seed yield plant^{-1} due to delay in sowing beyond second date. First (3.373 g) followed by second (3.326 g) sowing, which were at par with each other, produced maximum seed compared to other treatments. Each successive delay, thereafter, resulted decrease in the seed yield significantly, which was maximum in the last (23.42%) sowing.

Effect of P_2O_5

Application of P_2O_5 had significant influence on seed yield plant^{-1} at each successive increase in its level over lower level, but upto P2 (3.290 g) only. Higher level of P_2O_5 at P3 (3.220 g) was not found effective in increasing seed yield further. The maximum increase in seed yield was recorded in P2 (25.62%) over that in unfertilized treatment.

Effect of K_2O

Effect of K_2O was non significant at all levels of its application.

Interaction

Sowing time x P_2O_5 levels

Table 27(b) : Seed yield plant^{-1} (g) as influenced by sowing time x P_2O_5 levels

D/P	PO	P1	P2	P3	Mean
D1	2.828	3.150	3.854	3.662	3.373
D2	2.756	3.356	3.545	3.286	3.236
D3	2.678	2.804	2.882	3.240	2.901
D4	2.216	2.545	2.881	2.693	2.583
Mean	2.619	2.963	3.290	3.220	

D x P

S.E. (m)± 0.117

C.D. at 5% 0.324

It is seen from the data presented in Table 27 (b) that, interaction effect between sowing time x P_2O_5 levels was found significant

when the data was pooled. First sowing in combination with P2 followed by P3 exhibited significantly higher seed yield plant^{-1} over other treatment combinations, but both these combinations were similar with each other. Similary, both former combinations (DIP0 and DIP1) were also similar with each other. At second treatment of sowing, combination of P2 followed by P1 and P3 were superior over control combination, but did not vary significantly with one another. At third sowing, combination of P3 produced significantly more seed plant^{-1} over rest of the combination. However, at last sowing, combination of P2 was superior over control, and P1 combination, and was at par with other combination.

Briefly, treatment combination of DIP2 (3.854 g) produced significantly more seed plant^{-1} amongst all combinations but was at par with DIP3 (3.662 g) as well as D2P2 (3.545 g) also.

4.4 Yield studies

4.4.1 Seed yield ha^{-1}

Data presented in Table 28 revealed that, mean Seed yield ha^{-1} was 2.507 and 0.949 in 1994-95 and 1995-96 respectively. Seed yield obtained in first year was nearly more than double than that recorded in the subsequent year of study.

Effect of sowing

There was profound effect of sowing treatments on seed production ha^{-1} in 1994-95 as well as in 1995-96 also. Data revealed adverse effect of late sowings on seed production during both the years. Early sowing at first (3.521 and 1.142 q ha^{-1}) followed by second (3.320 and 1.084 q ha^{-1}) date registered maximum seed yield than rest of the treatments under

Table 28 : Seed yield ha^{-1} (q) as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	3.521	1.142	2.331
D2	3.320	1.084	2.202
D3	1.981	0.909	1.445
D4	1.208	0.660	0.934
S.E. (m) ±	0.073	0.028	0.048
C.D. at 5%	0.233	0.089	0.144
Levels of phosphate			
P0	1.860	0.653	1.257
P1	2.525	0.941	1.733
P2	2.881	1.122	2.001
P3	2.764	1.080	1.922
S.E. (m) ±	0.070	0.021	0.039
C.D. at 5%	0.193	0.058	0.108
Levels of potash			
K0	2.419	0.926	1.672
K1	2.514	0.942	1.728
K2	2.522	0.958	1.740
K3	2.575	0.970	1.772
S.E. (m) ±	0.070	0.021	0.039
C.D. at 5%	N.S.	N.S	N.S
General mean	2.507	0.949	1.728

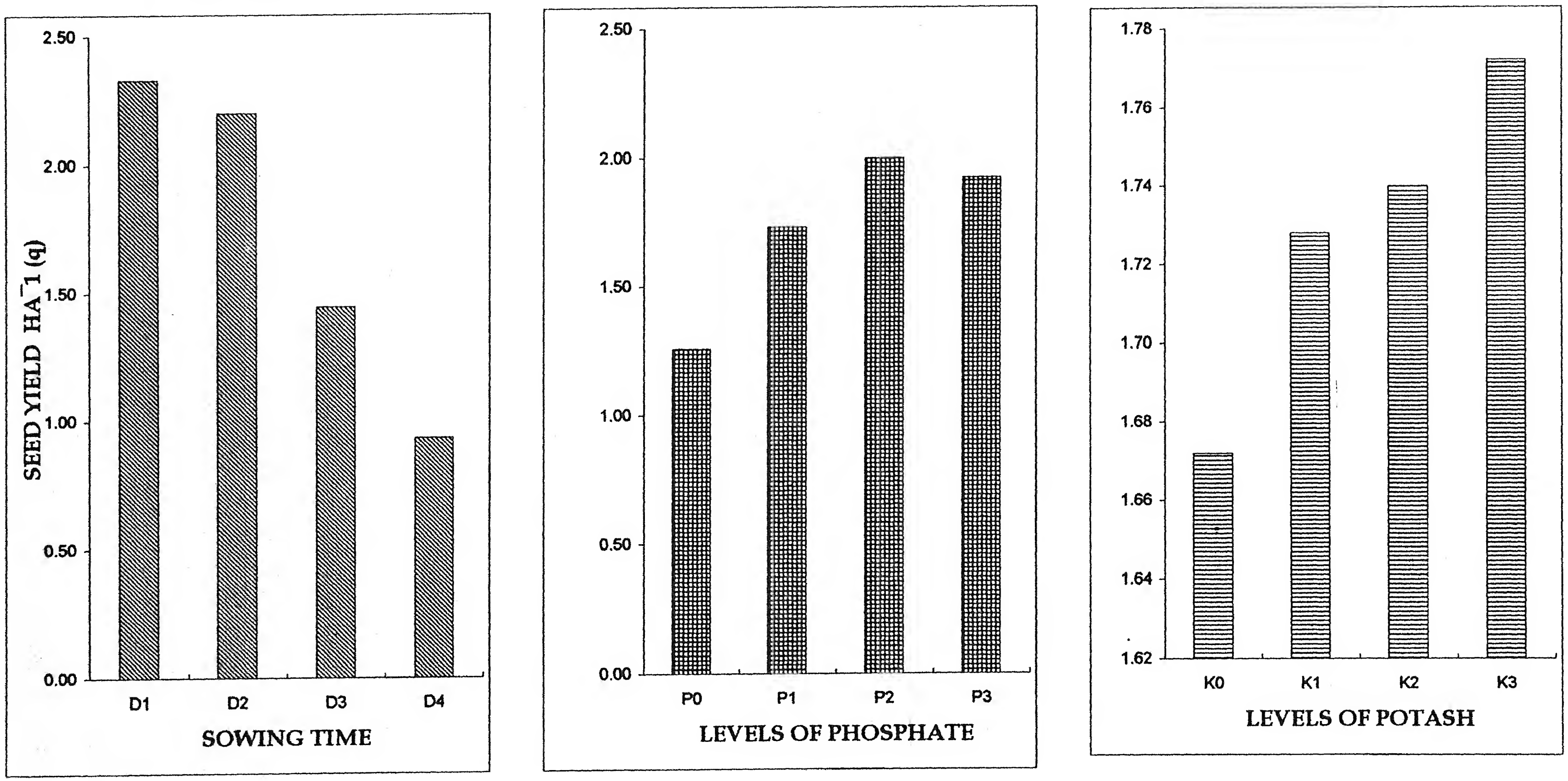


FIG.13: SEED YIELD (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS

study. Delayed sowing as in third, seed yield decreased by 1.560 and 0.233 q ha^{-1}, respectively over first. However, with highest delay as in last sowing seed yield was greatly decreased by 2.313 and 0.482 q ha^{-1}, respectively over normal sowing at first date.

Effect of P_2O_5

Graded levels of P_2O_5 significantly increased seed yield in 1994-95 and in 1995-96 also. There was progressive linerar increase in seed yield ha^{-1} with each successive increase in P_2O_5 level upto P2 treatment only. Further increase in P_2O_5 failed to increase seed yield further. The increase in seed yield was observed to the tune of 0.665, 1.021 and 0.904 q ha^{-1} in first year and 0.288, 0.469 and 0.427 q ha^{-1} in second year with addition of P1, P2 and P3, respectively over unfertilized treatment. This indicated maximum increase in seed yield upto P2 treatment only.

Effect of K_2O

Application of K_2O had no significant influence on seed yield ha^{-1} during both the years.

Interaction

Sowing time x P_2O_5 levels

Data presented in Table 28(a) revealed that, P2 treatment followed by P3 yielded significantly more seed ha^{-1} amongst all combinations of P_2O_5 at first sowing in the initial year. But, both the combinations of P2 and P3 did not differ among themselves at this date. Similarly, combination of P1 was also found significantly superior over P0 combination at this date. In second sowing, P_2O_5 under all levels proved better over control combination. Seed yield in combinations of P2, though was higher amongst all

Table 28 (a) : Seed yield ha^{-1} (q) as influenced by sowing time x levels of phosphate during 1994-95 and 1995-96

D/P	P0	P1	P2	P3	Mean
D1	2.412	3.509	4.212	3.949	3.520
	(0.802)	(1.169)	(1.339)	(1.257)	(1.142)
D2	2.480	3.440	3.767	3.594	3.320
	(0.707)	(1.054)	(1.325)	(1.251)	(1.084)
D3	1.612	1.985	2.130	2.197	1.981
	(0.627)	(0.863)	(1.093)	(1.052)	(0.909)
D4	0.937	1.165	1.414	1.315	1.208
	(0.475)	(0.677)	(0.730)	(0.759)	(0.660)
Mean	1.860	2.525	2.881	2.764	
	(0.653)	(0.941)	(1.122)	(1.080)	

	D x P
S.E. (m) ±	0.140 (0.042)
C.D. at 5%	0.387 (0.116)

(Figures in parenthesis refers to the year 1995 - 96)

combination of P_2O_5 but did not differ with other combinations of its application at this date. In third sowing seed yield was significantly higher at P3 followed by P2 combination compared to that in control but both these conbinations (D3P3 and D3P2) were similar to D3P1. At last sowing, also combination of P2 produced maximum seed over control combination but did not differ with rest of the combinations of P_2O_5 fertilisation.

During second year at all sowings, seed yield ha^{-1} was significantly increased due to P_2O_5 over control combination. At first sowing, P2 combination gave significantly higher seed yield over D1P1. Seed yield obtained in D1P3 did not vary to that obtained under D1P1 on one hand and D1P2 on the other. At second and third sowings, P2 followed by P3 combination showed consistantly higher seed yield over P0 combination. But both these conbinations were at par with each other. At last sowing seed yield found to be linearly increased but without affecting treatments significantly.

Briefly it was observed that, amongst all treatment combinations seed yield ha^{-1} was significantly higher in D1P2 (4.212 q ha^{-1}) in 1994-95 . In 1995-96 also seed yield ha^{-1} was higher in D1P2 (1.339 q ha^{-1}) followed by D2P2 (1.325 q ha^{-1}).

Pooled effects

The pooled data on seed yield ha^{-1} for two respective years are presented in Table 28 and depicted graphically in Fig. 13. Data revealed mean seed yield of 1.728 q ha^{-1}.

Effect of sowing

Data indicated that, seed yield ha^{-1} was similar in first

(2.331 q) and second sowing (2.202 q), but was significantly higher than all other treatments. The sowing when delayed as in third and last, seed yield ha^{-1} decreased by 0.886 and 0.757 q (38.0 and 34.37%) as well as 1.397 and 1.268 q (60.0 and 57.58%), respectively over first and second sowing.

Effect of P_2O_5

It was observed from the data that, seed yield ha^{-1} was significantly increased due to P_2O_5 application. At first increase (P1) in the input level, seed yield ha^{-1} was increased by 0.476 q (37.86%) over P0. With second increament of P_2O_5, seed yield again increased by 0.268 q (15.46%) over P2 treatment. However, further increment of P_2O_5 did not register further increase in the seed yield.

Effect of K_2O

Application of K_2O had no considerable influence on seed yield ha^{-1} at any level of its application.

Interaction

Sowing time x P_2O_5 levels

It is apparent from the data presented in Table 28(b) that, sowing time x P_2O_5 interaction found significant, wherein combination of P2 followed by P3 yielded significantly higher seed ha^{-1} amongst all combinations of P_2O_5 at first sowing. But both these combinations were at par with each other. Combination of P1 also gave significantly higher seed yield over control on this date. At second sowing, seed production was though significantly higher in all combinations of P_2O_5 over control, but combination of P2 also proved significantly superior over P1 and was at par with P3. At third sowing, there was a tendancy of increase in seed yield with increase in P_2O_5 levels and

Table 28 (b) : Seed yield ha^{-1} (q) as influenced by sowing time x levels of phosphate during (Pooled data for the year 1994-95 &1995-96)

D/P	P0	P1	P2	P3	Mean
D1	1.607	2.339	2.775	2.603	2.331
D2	1.593	2.246	2.546	2.422	2.202
D3	1.119	1.424	1.612	1.624	1.445
D4	0.706	0.921	1.071	1.040	0.934
Mean	1.257	1.733	2.001	1.992	

	D x P
S.E. (m) ±	0.072
C.D. at 5%	0.199

all combinations of P_2O_5 from P1 to P3 were superior over control, but remained at par with one another. In last sowing, combination of control treatment was significantly inferior than all combinations of P_2O_5 application. Seed yield was comparatively higher in D4P2, but was statistically similar to D4 P1 and D4P3. In brief, amongst all treatment combinations D1P2 (2.775 q ha^{-1}) proved to be best to achieve higher seed yield.

4.4.2 Straw yield

Data in respect of straw yield ha^{-1} as influenced by various treatments are presented in Table 29. The average straw yield to the tune of 19.87 and 51.70 q ha^{-1} was obtained in 1994-95 and 1995-96, respectively. It was noted that, straw production during second year was more as compared to that in the first year.

Effect of sowing

Effect of sowing was found to be significant in 1994-95 and in 1995-96 also. In both the years, earliest sowings at first (29.32 and 64.18 q ha^{-1}) followed by second (28.07 and 60.56 q ha^{-1}) date, which were at par, with each other yielded significantly higher straw over rest of the treatments. The sowing as delayed as in third, straw production decreased by 45.56 and 27.89% over first sowing in the two respective years. The highest delay as in last sowiing resulted highest reduction in straw production to the extent of 78.99% in first year and 44.20% in the second year, respectively over first treatment.

Effect of P_2O_5

Phosphate fertilization influenced straw production significantly during both the years. Data presented in Table 29 indicated linear

Table 29 : Straw yield ha^{-1} (q) and harvest index (%) as influenced by various treatments

Treatments	Straw yield ha^{-1} (q)			Harvest index (%)		
	1994 - 95	1995 - 96	Pooled	1994 - 95	1995 - 96	Pooled
Sowing time						
D1	29.32	64.18	46.75	10.72	1.74	6.23
D2	28.07	60.56	44.31	10.58	1.76	6.17
D3	15.96	46.28	31.12	11.04	1.92	6.48
D4	6.16	35.81	20.98	16.39	1.81	9.10
S. E. (m) ±	0.48	1.24	0.84	0.25	0.043	0.13
C. D. at 5%	1.53	3.96	2.54	0.80	0.13	0.38
Levels of phosphate						
P0	17.48	47.01	32.24	9.67	1.37	5.52
P1	19.14	50.78	34.94	11.65	1.82	6.73
P2	21.22	53.95	37.58	11.95	2.03	6.99
P3	21.67	55.10	38.38	11.21	1.92	6.61
S.E. (m) ±	0.45	0.98	0.64	0.22	0.037	0.11
C.D. at 5%	1.25	2.71	1.78	0.61	0.10	0.31
Levels of potash						
K0	19.27	50.72	34.99	11.15	1.79	6.47
K1	19.66	51.25	35.45	11.34	1.80	6.57
K2	20.15	52.09	36.12	11.12	1.80	6.46
K3	20.43	52.78	36.58	11.19	1.81	6.50
S.E. (m) ±	0.45	0.98	0.64	0.22	0.037	0.11
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	19.87	51.70	42.94	11.51	1.79	6.65

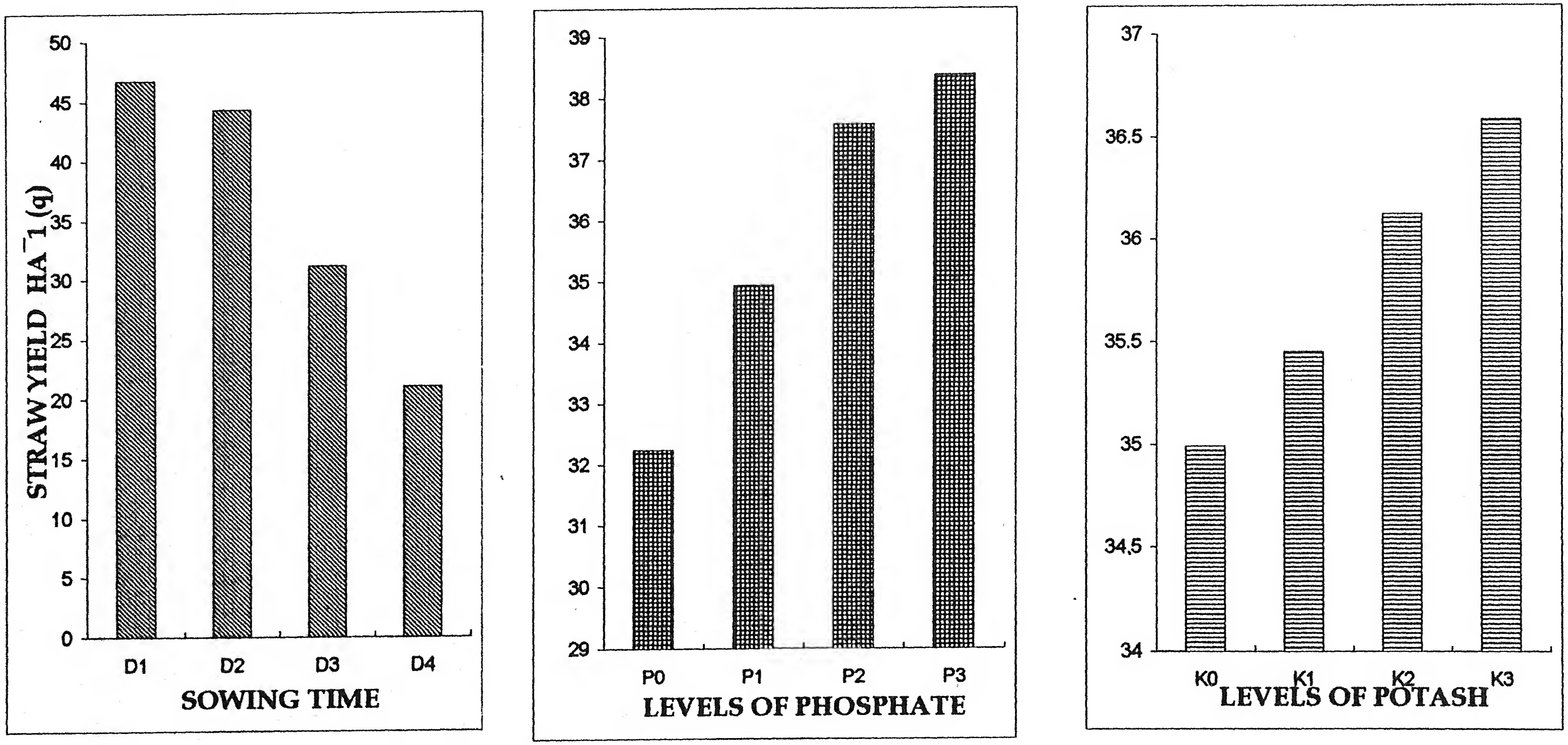


FIG.14: STRAW YIELD (POOLED) AS INFLUENCED BY VARIOUS TREATMENTS

increase n straw yield due to P_2O_5 application in both the years. But significant increase was achieved upto P2 treatment only. The increase in P_2O_5 level from P0 to P1, P1 to P2 and P2 to P3, increased straw yield by 1.66, 2.08 o.35 q ha^{-1} in first year and 3.77, 3.17, 1.15 q ha^{-1} in the second year, respectively over their respective lower levels.

Effect of K_2O

Increasing levels of K_2O from K0 to K3 did not influnce straw yield during both the years.

Interaction

Sowing time x P_2O_5 levels

Data presented in Table 29 (a) indicated significant influence of sowing time x P_2O_5 interaction on straw yield ha^{-1} during 1994-95 and 1995-96. In first year, in both early sowing (first and second) straw yield was significantly increased with each increamental dose of P_2O_5 upto P2 treatment. Straw yield at P3 treatment was also significantly higher than unfertilized treatment and P1, but was sililar to that recorded in P2 treatment. However, straw yield in third and last sowing was not affected by P_2O_5 levels, and in all treatments from P0 to P3 it was statistically similar. During second year at all sowings except last, straw yield was maximum at P3 followed by P2 combination over control. Similarly, combination of P3 was also found significantly superior over combination of P1, but at first and third sowing only. However, treatment differences within P0 and P1, P1 and P2 as well as P2 and P3 at first and third sowing, and within P1, P2 and P3 at second sowing, were non significant. In last sowing, straw yield was statistically similar in all combinations.

Table 29 (a) : Straw yield ha^{-1} (q) as influenced by sowing time x levels of phosphate during 1994-95 and 1995-96

D/P	P0	P1	P2	P3	Mean
D1	25.54	28.06	31.56	32.11	29.32
	(58.23)	(63.05)	(67.35)	(68.06)	(64.37)
D2	24.73	26.62	29.99	30.93	28.07
	(55.14)	(60.12)	(63.25)	(63.74)	(60.36)
D3	14.77	15.79	16.33	16.96	15.96
	(41.06)	(44.55)	(48.46)	(51.05)	(46.28)
D4	4.90	6.07	6.99	6.67	6.16
	(33.60)	(35.38)	(36.72)	(37.55)	(35.81)
Mean	16.88	19.23	21.42	21.97	
	(47.01)	(50.77)	(53.94)	(55.11)	

	D x P
S.E. (m) ±	0.90 (1.96)
C.D. at 5%	2.48 (5.43)

(Figures in parenthesis refers to the year 1995 - 96)

In brief, amongst all treatment combinations straw yield ha^{-1} was significantly higher in D1P3 combination, but was at par with D1P2, D2P3 and D1P2 during first year. Similarly, during second year also though treatment combination of D1P3 recorded maximum straw, but was similar to combination of D1P2 and D2P3. The treatment combination of D2P3 was also found at par with D2P2, D1P1 as well as D2P1.

Pooled effects

Table 29 indicated mean straw production of 42.94 q ha^{-1} when the data of 1994-95 and 1995-96 was pooled. The same is depicted graphically in Fig. 14.

Effect of sowing

Similar trend of earlier years was reflected in pooled data wherein first (46.75 q ha^{-1}) followed by second (44.31 q ha^{-1}) sowing produced significantly higher straw amongst all treatments, but remained at par with each other. The decrease in straw yield was reached to the tune of 33.43% and 55.12% due to delay sowing on third and last date, respectively over first.

Effect of P_2O_5

Data indicated significant influence of P_2O_5 on straw yield ha^{-1}, which found to be increased linearly at all levels of its application, but signigicant increase was achieved upto P2 treatment only. Amongst all treatment straw yield was lowest when no P_2O_5 was applied. First increament of P_2O_5 at the rate of P1 added 2.70 q straw ha^{-1} over P0 treatment. With second increament of P_2O_5 at P2, straw yield increased by 2.64 q ha^{-1} over P1. But when last increament of P3 was made, it added only 0.80 q straw ha^{-1} over

its lower level of appplication.

Effect of K_2O

Pooled data did not show significant influence of K_2O on straw production ha^{-1}.

Interaction

Sowing time x P_2O_5 levels

Data presented in Table 29(b) revealed that, at first and second sowing, each successive increase in P_2O_5 level proved significantly superior and increased straw yield (ha^{-1}) over preceeding level upto P2 treatment. At third sowing, application of P3, over unferlilized treatment and P1, and application of P2 over P0 treatment were found superior. But differences amongst P0 and P1, P1 and P2 as well as P2 and P3 treatments were non significant. In last sowing however, straw yield ha^{-1} was linearly increased with increasing levels of P_2O_5, but increase brought by every treatment did not reach a level of significance.

In brief, amongst all treatment combinations straw yield ha^{-1} found to be significantly maximum at D1P3, but this combination was at par with D1P2 and D2P2 , and further D1P1 with D2P2 also.

4.4.3 Harvest index

Harvest index was calculated on the basis of seed yield and straw yield (q ha^{-1}) and is presented in Table 29.

Mean harvest index was observed to be 11.51, 1.79 and 6.65 in 1994-95, 1995-96 and when the data was pooled, respectively

Table 29 (b) : Straw yield ha^{-1} (q) as influenced by sowing time x levels of phosphate (pooled data for the year 1994-95 & 1995-96)

D/P	P0	P1	P2	P3	Mean
D1	41.88	45.55	49.45	50.08	46.74
D2	39.93	43.37	46.62	47.35	44.31
D3	27.91	30.17	32.39	34.00	31.11
D4	19.24	20.72	21.85	22.11	20.98
Mean	32.24	34.95	37.58	38.38	

	D x P
S.E. (m) ±	1.08
C.D. at 5%	2.99

Effect of sowing

Various sowing treatments differed significantly in respect of harvest index throughout the study. In first year harvest index was increased with lateness in sowing and was significantly higher in last sowing (16.39%) than rest of the treatments, which were at par with one another. In second year also harvest index was significantly higher in delayed sowing at third (1.92%) date amongst all.

Effect of P_2O_5

Application of P_2O_5 registered significant influence on harvest index throughout the study. In 1994-95, at all levels from P1 to P3, harvest index was significantly higher than unfertilized treatment. But these treatments (P1 to P3) were at par within themselves. In 1995-96, each higher dose of P_2O_5 recorded significantly higher H.I. over its respective lower dose upto P2 (2.03%). However, harvest index in P3 was significantly higher than P0 and similar to P1 treatment. In pooled data, P1 to P3 were significantly supeior over control treatment, but P2 (6.99%) was also superior over P3. However, differences within P1 and P2 as well as P1 and P3 were non siginificent.

Effect of K_2O

Graded levels of K_2O did not influence harvest index significantly throughout the study.

Interaction

None of the interactions were found to be significant during the course of investigation.

4.5 Quality studies

Effect of various treatments on seed quality parameters such as test weight, seed protein and germination, recorded during 1994-95, 1995-96 and also when the data was pooled are presented in respective Tables.

4.5.1 Test weight

Data presented in Table 30 indicated mean test weight of 3.591, 2.610 and 3.099 g, in first year, second year and on pooled basis.

Effect of sowing

Test weight was found to be significantly increased due to various sowings except during second year. In 1994-95, first (3.766 g) followed by second (3.677 g) sowing recorded significantly higher test weight than third and last, but both these tratements did not differ within them significantly. The test weight thereafter decreased as observed in the third and was lowest in the last, but these treatments also did not differ within them signigicantly. In 1995-96, none of the treatments showed significant influence on test weight, although was slightly increased in the delayed treatments. Pooled data revealed similar trend as that observed in first year Both earliest sowings of first (3.170 g) followed by second (3.134 g) showed significantly higher test weight than both latter sowings. First with second, as well as third with last were similar in effects.

Effect of P_2O_5

Application of P_2O_5 favourably increased test weight throughout the study. Treatment P3 (3.153 g) followed by P2 (3.141 g) and P1 (3.116 g) showed significantly higher test weight than control teatment. But differences beyond P1 were non significant.

Table 30 : Test weight (g) as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	3.766	2.574	3.170
D2	3.677	2.592	3.134
D3	3.468	2.629	3.048
D4	3.451	2.640	3.045
S.E. (m) ±	0.034	0.024	0.021
C.D. at 5%	0.109	N.S.	0.061
Levels of phosphate			
P0	3.505	2.463	2.984
P1	3.598	2.634	3.116
P2	3.620	2.663	3.141
P3	3.637	2.670	3.153
S.E. (m) ±	0.027	0.021	0.017
C.D. at 5%	0.075	0.058	0.047
Levels of potash			
K0	3.563	2.596	3.079
K1	3.580	2.604	3.092
K2	3.607	2.610	3.108
K3	3.610	2.630	3.120
S.E. (m) ±	0.027	0.021	0.017
C.D. at 5%	N.S.	N.S.	N.S.
General mean	3.591	2.610	3.099

Effect of K_2O

There was no significant increase in test weight due to K_2O in 1994-95, 1995-96 and also when the data was were pooled. 9

Interaction

Throughout the investigation, effect of interactions on test weight were non significant.

4.5.2 Seed protein

Data presented in Table 31 revealed mean protein content of 23.30% in 1994-95, 21.16% in 1995-96 and 22.23% when the data was pooled.

Effect of sowing

Various sowings under study did not influence protein content noticeably neither in individual year nor when the data was analysed on poole basis.

Effect of P_2O_5

Data indicated significant influence of P_2O_5 on protein content throughout the study. With each increase in P_2O_5 level, there was linear increase in protein content upto P3 treatment. However, all the treatments from P1 to P3 did not differ within them significantly but were superior over unfertilized treatment.

Effect of K_2O

Data did not revealed significant influence of K_2O on protein content throughout the study.

Table 31 : Seed protein (%) as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	23.50	21.02	22.26
D2	23.34	21.14	22.24
D3	23.20	21.22	21.21
D4	23.16	21.28	22.22
S.E. (m) ±	0.20	0.16	0.13
C.D. at 5%	N.S.	N.S.	N.S.
Levels of phosphate			
P0	22.52	20.06	21.29
P1	23.38	21.38	22.38
P2	23.60	21.54	22.57
P3	23.70	21.68	22.69
S.E. (m) ±	0.21	0.18	0.14
C.D. at 5%	0.58	0.49	0.39
Levels of potash			
K0	23.08	21.05	22.06
K1	23.34	21.14	22.24
K2	23.36	21.21	22.28
K3	23.40	21.26	22.33
S.E. (m) ±	0.21	0.18	0.14
C.D. at 5%	N.S.	N.S.	N.S.
General mean	23.30	21.16	22.23

Interaction

Interaction effects were also non significant throughout the Investgation.

4.5.3 Seed germination

Data on seed germination, presented in Table 32 indicated mean germination of 44.64, 31.69, 38.32 in first year, second year and in pooled respectively.

Effect of sowing

Seed germination was found to be significantly improved due to delay in sowing throughout the study except in 1995-96, when differences within all treatments were non significant. In 1994-95 and when the data was pooled, seed obtained from last sowing (47.52 and 39.99) showed significantly higher germination than the seed obtained from all treatments except third which was at par with this treatment. Similarly, seed obtained from third sowing (46.66 and 39.47) also showed higher germination than first and second sowing's seed. The seed received from first sowing although showed lowest germination than those obtained from rest of the sowings, but was similar with those of second sowing's seed.

Effect of P_2O_5

In 1994-95, 1995-96 and also when the data was pooled, seed obtained from P1 to P3 treatments recorded signigicantly higher geermination than the seed obtained from control treatment. However differences amongst P1 to P3 did not show significant variation.

Table 32 : Lab. germination as influenced by various treatments

Treatments	1994-95	1995-96	Pooled
Sowing time			
D1	41.55 (44.0)	31.24 (26.9)	26.51 (35.45)
D2	42.82 (46.2)	31.50 (27.3)	37.29 (36.75)
D3	46.66 (52.9)	31.95 (28.0)	39.47 (40.45)
D4	47.52 (54.4)	32.08 (28.2)	39.99 (41.30)
S.E. (m) ±	0.52	0.30	0.30
C.D. at 5%	1.66	N.S.	0.89
Levels of phosphate			
P0	42.36 (45.4)	29.80 (24.7)	36.27 (35.05)
P1	44.94 (49.9)	32.14 (28.3)	38.70 (39.10)
P2	45.40 (50.7)	32.33 (28.6)	39.00 (39.65)
P3	45.86 (51.5)	32.52 (28.9)	39.35 (40.20)
S.E. (m) ±	0.40	0.31	0.25
C.D. at 5%	1.12	0.85	0.71
Levels of potash			
K0	42.82 (46.2)	31.37 (27.10)	37.23 (36.65)
K1	44.71 (49.5)	31.63 (27.50)	38.35 (38.50)
K2	45.34 (50.6)	31.82 (27.80)	38.76 (39.20)
K3	45.69 (51.2)	31.95 (28.00)	39.00 (39.60)
S.E. (m) ±	0.40	0.31	0.25
C.D. at 5%	1.12	N.S.	0.71
General mean	44.64 (49.37)	31.69 (27.64)	38.32 (38.49)

(Figures in parenthesis refers to germination percentage)

Effect of K_2O

Application of K_2O exhibited significant influence on seed germination in 1994-95 and when the data was pooled. The seed received from K0 treatment showed lowest germination amongst all treatments. But, when K_2O dose was increased to K1 level, seed germination was significantly increased over K0. However, further increase in K_2O upto K2 and K3 did not enhance seed germination considerably and all the treatments from K1 to K3 were found to be at par with one another.

Interaction

Interaction effects were non singnificant during both the years and also in pooled data.

4.6 Chemical studies

4.6.1 Nutrient concentration in plant

Nitrogen, phosphorus and potassium concentration in whole plant was estimated at 80% flowering and at harvest in 1994-95, 1995-96 and the data are presented in Table 33 and 34, respectively.

4.6.1.1 Nutrient concentration at 80% flowering

Table 33 Indicated that, mean nitrogen, phosphorus and potassium contents in plant were observed to be 2.185, 0.114 and 1.677%; 2.078, 0.183 and 1.434%; and 2.131, 0.148 and 1.556%, during first year, second year and on pooled basis, respectively.

Effect of sowing

Data indicated that, in 1994-95, first sowing had significantly higher contents of nitrogen (2.242%), phosphorus (0.117%) and

Table 33 : N,P,K contents in plant (%) at 80% flowering as influenced by various treatments

Treatments	1994 - 95			1995 - 96			Pooled		
	N	P	K	N	P	K	N	P	K
Sowing time									
D1	2.242	0.117	1.714	2.065	0.181	1.416	2.153	0.149	1.565
D2	2.210	0.116	1.690	2.071	0.182	1.420	2.140	0.149	1.555
D3	2.175	0.113	1.663	2.083	0.185	1.432	2.129	0.149	1.547
D4	2.112	0.111	0.640	2.092	0.186	1.468	2.102	0.148	1.554
S. E. (m) ±	0.019	0.0011	0.014	0.023	0.0020	0.015	0.015	0.0011	0.010
C. D. at 5%	0.060	0.0035	0.045	N.S.	N.S.	N.S.	0.046	N.S.	N.S.
Levels of phosphate									
P0	2.173	0.101	1.664	2.051	0.166	1.423	2.112	0.133	1.543
P1	2.184	0.112	1.675	2.074	0.179	1.430	2.129	0.145	1.552
P2	2.188	0.119	1.680	2.088	0.190	1.440	2.138	0.154	1.560
P3	2.195	0.125	1.688	2.098	0.199	1.443	2.146	0.162	1.565
S.E. (m) ±	0.018	0.0013	0.015	0.019	0.0022	0.017	0.014	0.0012	0.011
C.D. at 5%	N.S.	0.0036	N.S.	N.S.	0.0061	N.S.	N.S.	0.0035	N.S.
Levels of potash									
K0	2.168	0.113	1.590	2.067	0.181	1.352	2.117	0.147	1.471
K1	2.178	0.114	1.648	2.071	0.183	1.412	2.124	0.148	1.530
K2	2.193	0.115	1.709	2.083	0.184	1.468	2.138	0.149	1.588
K3	2.201	0.115	1.760	2.090	0.186	1.504	2.145	0.150	1.632
S.E. (m) ±	0.018	0.0013	0.015	0.019	0.0022	0.017	0.014	0.0012	0.011
C.D. at 5%	N.S.	N.S.	0.041	N.S.	N.S.	0.047	N.S.	N.S.	0.031
General mean	2.185	0.114	1.677	2.078	0.183	1.434	2.131	0.148	1.556

potassium (1.714%) than third and last treatment. Similarly, second sowing also recorded more contents of N (2.210%), P (0.116%) and K (1.690%) than last, but did not differ with the first sowing on one hand and with third sowing on the other. Third sowing also proved significantly superior over last but in respect N content only. However, in respect of P and K both, third and last sowings were at par with each other. In 1995-96, sowing treatments did not influence nitrogen, phosphorus and potassium contents significantly. Pooled data indicated superiority of first sowing over last in respect of N content only, but was at par with rest of the sowings. Similarly, sowing treatments from second to last were also at par with one another. Regarding P and K concentration all the sowings were statistically similar.

Effect of P_2O_5

Application of P_2O_5 did not show significant influence on nitrogen and potassium contents during 1994-95, 1995-96 and also when the data was pooled. However, phosphorus concentration was significantly increased due to P_2O_5 throughout the study. With each successive increase in P_2O_5 there was significant increase in phosphorus concentration over its lower level and reached to maximum in P3 (0.162%).

Effect of K_2O

Fertilization with K_2O, did not influence nitrogen and phosphrous concentration significantly throughout the study. However, there was significant increase in potassium content. In 1994-95, each higher level of K_2O brought significant increase in K concentration over its lower level and was highest in K3. In 1995-96, each higher level proved to be significantly superior over each lower level except K3, which was at par with K2. Pooled

data however revealed significant increase in K_2O concentration at each successive increase in its level over preceeding level and attained maximum in K3 (1.632%).

Interaction

Interaction effects were non significant during individual years as well as on pooled basis also.

4.6.1.2 Nutrient concentration at harvest

Data presented in Table 34 revealed that, mean nitrogen, phosphorous and potassium concentration in whole plant was 1.342, 0.071 and 0.835% in 1994-95; 1.115, 0.129 and 0.700% in 1995-96; and 1.228, 0.099 and 0.767% when the data was analysed on pooled basis. It was also noted that, nutrient concentration declined with the age of crop throughout the study.

Effect of sowing

Data did not indicate significant influence of various sowings on nitrogen, phosphorus and potassium concentration in whole plant in 1994-95, 1995-96 and also when it was pooled.

Effect of P_2O_5

Graded levels of P_2O_5 had no significant influence on nitrogen and potassium concentration, but phosphorus concentration was significantly increased throughout the study. At all levels of P_2O_5 from P1 to P3, (0.102, 0.104 and 0.106%) there was significantly higher concentration of phosphorus than unfertilized treatment. However, all the treatments from P1 to P3 did not differ significantly in their performance.

Table 34 : N,P,K contents in plant (%) at harvest as influenced by various treatments

Treatments	1994 - 95			1995 - 96			Pooled		
	N	P	K	N	P	K	N	P	K
Sowing time									
D1	1.360	0.072	0.847	1.104	0.126	0.691	1.232	0.099	0.769
D2	1.354	0.071	0.840	1.106	0.129	0.697	1.230	0.100	0.768
D3	1.331	0.071	0.828	1.123	0.130	0.705	1.227	0.100	0.766
D4	1.323	0.070	0.825	1.128	0.131	0.709	1.225	0.100	0.767
S. E. (m) ±	0.016	0.009	0.008	0.013	0.0019	0.0070	0.010	0.0046	0.0053
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Levels of phosphate									
P0	1.330	0.064	0.828	1.103	0.113	0.694	1.216	0.088	0.761
P1	1.341	0.072	0.832	1.113	0.132	0.696	1.227	0.102	0.764
P2	1.345	0.074	0.837	1.120	0.134	0.705	1.232	0.104	0.771
P3	1.352	0.075	0.843	1.125	0.137	0.707	1.238	0.106	0.775
S.E. (m) ±	0.015	0.0011	0.010	0.011	0.0021	0.0093	0.009	0.0018	0.0068
C.D. at 5%	N.S.	0.0030	N.S.	N.S.	0.0058	N.S.	N.S.	0.0050	N.S.
Levels of potash									
K0	1.334	0.070	0.790	1.106	0.127	0.654	1.220	0.098	0.722
K1	1.339	0.071	0.837	1.111	0.128	0.706	1.225	0.099	0.771
K2	1.346	0.071	0.853	1.119	0.130	0.715	1.232	0.100	0.784
K3	1.349	0.072	0.860	1.125	0.131	0.727	1.237	0.101	0.793
S.E. (m) ±	0.015	0.0011	0.010	0.011	0.0021	0.0082	0.009	0.0018	0.008
C.D. at 5%	N.S.	N.S.	0.028	N.S.	N.S.	0.023	N.S.	N.S.	0.023
General mean	1.342	0.071	0.835	1.115	0.129	0.700	1.228	0.099	0.767

Effect of K_2O

Significant influence of K_2O was not observed on nitrogen and potassium content either in individual year or when the data was examined on pooled basis. The concentration of potassium in plant tissue however significantly increased due to K_2O application throughout the study. All levels of K_2O, from K1 to K3 (0.771, 0.784 and 0.793%) shwoed significantly higher concentration of potassium over unfertiliaed treatment. But all these treatments (K1 to K3) did not differ significantly from one another.

Interaction

None of the interactions influenced N,P,K, concentration in whole plant neither in individual year nor on pooled basis.

4.6.2 Nutrient uptake

Data on total uptake of N, P and k, estimated at 80% flowering stage are presented in Table 35. It revealed that the mean total uptake was 57.45, 3.0 and 43.99 kg ha^{-1} in 1994-95; 158.01, 13.97 and 109.03 kg ha^{-1} in 1995-96; and 99.17, 8.48 and 76.52 kg ha^{-1} on pooled basis. Total uptake of these nutrients was more during second year as compared to that in the initial year of study.

Effect of sowing

Nitrogen

Sowing treatments showed substantial effect on total uptake of nitrogen throughout the study. It was observed that, nitrogen uptake was decreased due to delay in sowing during both the years and when the data was pooled. In 1994-95, amongst all treatments, total uptake of nitrogen was significantly maximum in first sowing (91.42 kg ha^{-1}) and decreased signifi-

Table 35 : Total nutrient uptake (kg ha^{-1}) at 80% flowering as influenced by various treatments

Treatments	1994 - 95			1995 - 96			Pooled		
	N	P	K	N	P	K	N	P	K
Sowing time									
D1	91.42	4.87	69.99	181.93	15.96	125.29	136.67	10.41	97.64
D2	85.63	4.39	65.38	185.84	16.31	128.12	135.73	10.35	96.75
D3	46.80	2.43	35.79	140.79	12.48	97.26	93.79	7.45	66.52
D4	19.27	0.96	14.15	109.65	9.77	75.84	64.46	5.36	44.99
S. E. (m) ±	1.32	0.066	1.01	3.38	0.33	2.39	1.81	0.17	1.30
C. D. at 5%	4.22	0.21	3.23	10.81	1.05	7.64	5.47	0.49	3.90
Levels of phosphate									
P0	50.60	2.35	38.82	137.21	11.10	95.22	93.90	6.72	67.02
P1	54.63	2.80	41.89	156.33	13.48	107.76	105.48	8.14	74.82
P2	57.91	3.15	44.46	169.91	15.44	117.18	113.91	9.29	80.82
P3	60.03	3.41	46.08	175.74	16.70	120.87	117.88	10.05	83.47
S.E. (m) ±	1.14	0.059	0.91	3.20	0.28	2.15	1.70	0.14	1.17
C.D. at 5%	3.16	0.16	2.52	8.78	0.77	N.S.	4.68	0.38	3.20
Levels of potash									
K0	53.81	2.77	39.46	154.29	13.51	100.92	104.05	8.14	70.19
K1	55.32	2.89	41.82	158.12	13.80	107.81	106.72	8.34	74.81
K2	56.57	2.98	44.10	162.05	14.39	114.17	109.31	8.68	79.13
K3	57.41	3.01	45.93	164.12	14.70	118.13	110.76	8.85	82.03
S.E. (m) ±	1.14	0.059	0.91	3.20	0.28	2.15	1.70	0.14	1.17
C.D. at 5%	3.16	0.16	2.52	8.78	0.77	5.96	4.68	0.38	3.20
General mean	57.45	3.0	43.99	158.01	13.97	109.03	99.17	8.48	76.52

cantly thereafter as observed in D2 followed by D3 and D4. However, in 1995-96 and in pooled data, first (181.93 and 136.67 kg ha^{-1}) sowing showed significantly more uptake than rest of the treatments but were at par with each other. Consecutive delay in sowing resulted significant decrease in nitrogen uptake as recorded in third and the last sowing.

Phosphorus

Total uptake of P found to have significantly increased due to early sowing throughout the study. During 1994-95, first sowing (4.87 kg ha^{-1}) showed significantly more uptake amonst all tratements. The second sowing was also significantly superior than latter two. Third was also better than the last. Similar trend was observed in subsequent year and when the data was pooled , except second sowing, which was at par with first. During second year and in pooled data total uptake recorded by first and second sowing was 15.96 and 10.41 kg ha^{-1}; and 16.31 and 10.35 kg ha^{-1} respectively.

Potassium

Data in Table 35 indicated significant increase in K uptake due to early sowing throughout the study. First sowing (69.99 kg ha^{-1}) during first year, and first (125.29 and 97.64 kg ha^{-1}) as well as second sowing (128.12 and 96.75 kg ha^{-1}) during second year and also in pooled data exhibited significantly more uptake of potassium than rest of the treatments. However, both these treatments did not differ within them significantly except during first year. From second sowing onwards in the first year, and from third sowing onwards in the second year and in pooled data the total uptake of K was significantly decreased with each successive delay, which was low in third and lowest in the last sowing.

Effect of P_2O_5

Nitrogen

It was observed that, during 1994-95, 1995-96 as well as when the data was pooled, total uptake of nitrogen was significantly increased due to P_2O_5 application. With each increase in the input level, nitrogen uptake was significantly increased over its respective lower level except K3 (117.88 kg ha^{-1}), which did not differ significantly with its lower level at P2 (113.91 ha^{-1}).

Phosphorus

Graded levels of P_2O_5 exhibited significant influence on its total uptake throughout the study. It is apparent from the data that, each higher level of P_2O_5 registered significant increase in total uptake of P over lower level and reached to maximum in the last treatment (10.05 kg ha^{-1}).

Potassium

Significant increase in total uptake of K was also recorded during both the years and when the data was analysed on pooled basis. It was observed that, as P_2O_5 dose increased, the total uptake of K was linearly increased. But significant increase was recorded upto application of P2 (80.82 Kg ha^{-1}) only. Further increase in P_2O_5 upto P3 (83.47 kg ha^{-1}) did not show significant increase over P2.

Effect of K_2O

Nitrogen

It could be observed from the data that, during first and second year, K_2O at the rate of K3 recorded significantly more uptake of

nitrogen than unfertilized treatment. However it (K3) did not vary signifcantly with K1 as well as K2 also. Treatment K0 although recorded lowest uptake amongst all, but it also did not vary with K1 and k2. However, in pooled data, both latter treatments at K3 (110.76 kg ha^{-1}) followed by K2 (109.31 kg ha^{-1}) proved significantly superior over unfertilized treatment, but appeared to be similar with each other as well as with K1. Former two treatments also found to be similar in their performance.

Phosphorus

Total uptake of P increased significantly due to higher rates of K_2O during 1994-95, 1995-96 and in pooled data also. In 1994-95, K3 followed by K2 showed significantly higher uptake than K0, but both these treatments did not vary with each other as well as with K1 also . Similarly, K0 and K1 also did not vary significantly amongst themselves during this year. However, during 1995-96 and when the data was pooled, K2 (14.39 and 8.68 kg ha^{-1}) over K0, and k3 (14.70 and 8.85 kg ha^{-1}) over K0 as well as K1 recorded signifcantly more uptake. But both these treatments with each other, as well as K2 with K1, and K1 with K0 were at par.

Potassium

Data indicated that, graded levels of K_2O promoted significant increase in its total uptake at higher rates of application throughout the study. During 1994-95, k3 followed by K2 over K0, and K3 also over k1 recorded significantly more uptake of K. However K3 and K2 with each other, as well as K2 with K1 were at par. Similarly, K1 was also found at par with K2. During 1995-96, and when the data was pooled, each successive increase in K_2O level proved to be superior and recorded significantly more

uptake over its preceeding level except K3 (82.03 kg ha^{-1}) which did not show significant variation with K2 (79.13 kg ha^{-1}).

Interaction

During both the years and in pooled data none of the interactions showed significant variation in total uptake of nitrogen, phosphorus and potassium.

4.5 Soil properties

Residual fertility status of soil

After harvest of the crop grown during 1994-95 and 1995-96, treatmentwise samples were collected and analysed for content of available N, P and K to find out residual fertility left over in the soil. The datc are presented in Table 36.

Mean available N, P and K, left over in soil were observed to be 229.14, 13.81 and 281.21 kg ha^{-1} in 1994-95; 239.21, 16.34 and 311.22 kg ha^{-1} in 1995-96; and 234.16, 15.07 and 321.27 kg ha^{-1} as pooled means. From these results it can be inferred that fertilization of crop enriched the soil considerably.

Effect of sowing

Data did not show significant influence of various sowings on availabe N, P and K left over in soil during first year, second year and also when pooled. It was observed that, available nitrogen found to be increased numerically due to early sowing which was maximum in first as against minimum in the last sowing. Contray to this, contents of available P and K, showed increasing tendancy with delay in sowing, which were highest in the last as against lowest in the first.

Table 36 : Available N,P,K in soil (kg ha^{-1}) after harvest as influenced by various treatments

Treatments	1994 - 95			1995 - 96			Pooled		
	N	P	K	N	P	K	N	P	K
Sowing time									
D1	234.25	13.40	277.20	243.44	15.99	306.02	238.81	14.69	291.61
D2	232.15	13.67	279.41	242.80	16.23	309.21	237.50	14.95	294.31
D3	227.87	14.01	283.25	236.62	16.43	313.89	232.24	15.22	298.57
D4	222.38	14.17	284.98	233.97	16.71	315.78	228.17	15.45	300.38
S. E. (m) ±	5.35	0.37	5.12	5.14	0.46	5.80	3.81	0.29	3.89
C. D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Levels of phosphate									
P0	224.75	9.46	278.50	233.64	11.22	306.29	229.19	10.35	292.39
P1	227.98	11.33	279.95	237.33	14.40	310.45	232.65	12.86	295.20
P2	231.32	15.13	282.33	240.97	17.93	312.30	236.14	16.53	297.31
P3	232.70	19.30	284.06	244.89	21.81	315.86	238.79	20.55	299.96
S.E. (m) ±	5.18	0.43	5.62	4.90	0.51	6.31	3.56	0.33	4.22
C.D. at 5%	N.S.	1.19	N.S.	N.S.	1.41	N.S.	N.S.	0.92	N.S.
Levels of potash									
K0	226.79	13.38	243.82	235.53	15.60	270.20	231.09	14.79	257.01
K1	228.12	13.70	273.26	239.36	16.35	304.02	233.68	15.02	288.64
K2	230.09	13.85	292.39	240.57	16.50	325.78	235.27	15.17	309.85
K3	231.75	14.32	315.37	241.37	16.92	344.90	236.50	15.32	330.08
S.E. (m) ±	5.18	0.43	5.62	4.90	0.51	6.31	3.56	0.33	4.22
C.D. at 5%	N.S.	N.S.	15.57	N.S.	N.S.	17.48	N.S.	N.S.	11.69
General mean	229.14	13.81	281.21	239.21	16.34	311.22	234.16	15.07	296.27

Effect of P_2O_5

Increasing levels of P_2O_5 from P0 to P3 had no conspicuous effect on available N and K in soil throughout the study. However, phophorus content was linearly and significantly increased with each addition of input level. Unfertilized treatment was most inferior amongst all. But with subsequent increase in P_2O_5 dose, soil P status was increased to the tune of 24.25 28.53 and 24.31% in P1, P2 and P3 over their respective lower levels.

Effect of K_2O

Application of K_2O did not register any influence on available N and P left over in soil throughout the experimentation. However, there was a tendancy of increase in available K in soil with increase in K_2O levels. During both the years and when the data was pooled, available K was observed to be significantly increased with each inrease in K_2O level. Addition of each unit proved to be significantly superior over preceeding unit and K contents were maximum with addition of K3. The increase brought by K1, K2 and K3 treatments was noted to the extent of 12.31, 20.55 and 28.43% respectively over unfertilized treatment.

4.7.2 Soil mosture retention

Data on soil moisture at various growth stages during 1994-95, 1995-96 and when pooled, are presented in Table 37, 38 and 39.

In the initial year, moisture content was recorded prior to each sowing and fertilizer application. During second year, soil moisture at sowing time could not be recorded as the crop was established through auto seeding and without adopting normal sowing procedure. Data was not statistically analysed and inferences are based on mean numerical values.

Table 37: Available moisture (%) in soil at various stages as influenced by different treatments during 1994-95

Treatments	Sowing	Seedling	80% Flowering	Harvest
Sowing time				
D1	2.38	5.66	4.99	2.30
D2	3.46	7.21	4.51	2.45
D3	2.05	5.27	3.83	2.71
D4	4.10	3.11	3.01	2.81
Levels of phosphate				
P0	_	5.38	4.15	2.68
P1	_	5.35	4.11	2.58
P2	_	5.28	4.05	2.52
P3	_	5.24	4.03	2.49
Levels of potash				
K0	_	5.35	4.11	2.60
K1	_	5.34	4.10	2.57
K2	_	5.29	4.07	2.56
K3	_	5.27	4.06	2.54
General mean	2.99	5.31	4.08	2.56

Table 38: Available moisture (%) in soil at various stages as influenced by different treatments during 1995-96

Treatments	Sowing	Seedling	80% Flowering	Harvest
Sowing time				
D1	_	5.56	7.64	4.13
D2	_	5.60	7.86	4.19
D3	_	5.91	8.17	4.50
D4	_	6.26	8.74	4.92
Levels of phosphate				
P0	_	5.89	8.16	4.48
P1	_	5.85	8.14	4.46
P2	_	5.84	8.07	4.42
P3	_	5.75	8.04	4.38
Levels of potash				
K0	_	5.90	8.13	4.49
K1	_	5.83	8.12	4.44
K2	_	5.81	8.09	4.42
K3	_	5.79	8.07	4.39
General mean	_	5.83	8.10	4.43

Table 39: Available moisture (%) in soil at various stages as influenced by different treatments (Pooled data for the year 1994-95 & 1995-96)

Treatments	Sowing	Seedling	80% Fowering	Harvest
Sowing time				
D1	2.38	5.61	6.31	3.21
D2	3.46	6.40	6.18	3.32
D3	2.05	5.59	6.00	3.60
D4	4.10	4.68	5.87	3.86
Levels of phosphate				
P0	–	5.63	6.15	3.58
P1	–	5.60	6.12	3.52
P2	–	5.56	6.06	3.47
P3	–	5.49	6.03	3.43
Levels of potash				
K0	–	5.62	6.12	3.54
K1	–	5.58	6.11	3.50
K2	–	5.55	6.08	3.49
K3	–	5.53	6.06	3.46
General mean	2.99	5.57	6.09	3.49

Mean moisture content at sowing time was 2.99%, and at latter stages (seeding, 80% flowering and at harvest) were 5.31, 4.08 and 2.56 during first year; and 5.83, 8.10 and 4.43% during second year respectively. The corresponding values in pooled data were 2.99, 5.57, 6.09 and 3.49% at respective stages reffered above.

Effect of sowing

Data indicated that, soil moisture did not follow regular pattern upto seedling stage during first year. Moisture contents were low in third sowing as against higher in the last at sowing time. At seeding stage there was large variation and last sowing showed lower moisture as against higher in the second in initial year. During second year, moisture content found linearly increased with lateness in sowing and were lower in first sowing as against higher in the last at this stage. At 80% flowering, soil moisture showed decreasing pattern with delay in sowing during first year, where as increasing pattern due to late sowing during second year. First sowing had higher soil moisture as against lower in the same treatment, however last sowing showed lower moisture as against higher in the same treatment during the two respective years. At harvest, soil moisture increased throughout the study due to lateness in sowing. First sowing exhibited lower content in first and second year as aginst higher in the last sowing. Pooled data revealed similar trend as that recorded in the initial year of study.

Effect of P_2O_5

Application of P_2O_5 did not influence moisture content noticeabley, but showed decreasing trend with increasing levels of P_2O_5 during both the years and when the data was pooled.

Effect of K_2O

Noticeable variation in moisture content did not observe due to K_2O application. However, there was a tendancy of decrease in soil moisture with increase in K_2O levels throughout the study.

4.8 Regression analysis

4.8.1 Production function for various sowing treatments

An attempt was made to workout physical and economic optima by fitting experimentl al data to a two variable response surfaces. All twelve sets containing four sowing treatments, for the period of 1994-95, 1995-96 as well as pooled data, in combination with P_2O_5 and K_2O have been used for this purpose.

A two variable quadratic equation (equation 1) was used for computation of physical and economic optima in the present study. It was observed that, none of the twelve sets satisfied the requirement as b1, b2 and b5 were not positive (+) and b3 and b4 were not negative (-). Physical and economic optima for various sowings in combination with P_2O_5 and K_2O have not been worked out.

$$\hat{Y} = a + b1P + b2K + b3P^2 + b4K^3 + b5PK \text{ ------------------equation (1)}$$

The data was therefore subjected to simple quadratic equation for computation of optimum input level for P_2O_5. Pooled means of seed yield at various levels of P_2O_5 were considered for this purpose. Production function computed is given as under.

$$\hat{Y} = 1.2501 + 0.6424P - 0.1387\ P^2$$

A dose of 49.95 kg ha^{-1} of P_2O_5 was observed ot be optimum to predict a seed yield of 1.979 q ha^{-1} as against maximum dose of 57.89

kg, wherein predicted yield was 1.994 q for the period from first to last sowing (28^{th} June to 13^{th} August).

However, for computation of optimum and maximum input factor for P_2O_5 separately for each sowing, pooled means of seed yield obtained at respective sowings were taken into consideration. The production function computed for each of the sowings for P_2O_5 is given below.

A. First sowing (D1)

$$\hat{Y} = 1.5914 + 1.0204P - 0.2260 P^2$$

B. Second sowing (D2)

$$\hat{Y} = 1.5895 + 0.8613 P - 0.0732 P^2$$

C. Third sowing (D3)

$$\hat{Y} = 1.1161 + 0.3899 P - 0.0732 P^2$$

D. Last sowing (D4)

$$\hat{Y} + 0.6971 + 0.3069 P - 0.0637 P^2$$

The seed yield predicted thereon for different sowings at various levels of P_2O_5 are presented in Tables, 42, 43, 44 and 45 and depected in Fig. 15.

4.8.2 Optimum and maximum input levels for P_2O_5

Data presented in Table 42 and depicted in Fig. 15(a) revealed that, predicted yields were more or less nearer to that of actual yields. At first sowing, predicted seed yield was 2.743 q ha^{-1} at a maximum dose of 56.43 kg P_2O_5 ha^{-1}. This yield level was almost higher as compared to other levels of P_2O_5. On the other hand, a dose of 51.56 kg ha^{-1} and seed yield predicted thereon was found to be 2.734 q which was nearer to the

Table 40 : Optimum and maximum input factors with their corresponding yields at various sowing treatments

Sowing times	Optimum level of input	Yield of seed corresponding to optimum level	Maximum level of input	Yield of seed coresponding to maximum level of input
	Kg ha^{-1}	Q ha^{-1}	Kg ha^{-1}	Q ha^{-1}
	Phosphorus	Phosphorus	Phosphorus	Phosphorus
28th June	51.56	2.734	56.43	2.743
13th July	49.77	2.535	55.42	2.544
27th July	51.53	1.609	66.58	1.635
13th August	42.91	1.036	60.22	1.066

Table 41 : Observed and predicted yields of *S. hamata* ha^{-1} (q) as in influenced by levels of phosphate at various sowing treatments

Treatments	Phosphate levels	Observed yield ha^{-1} (q)	Predicted yield ha^{-1} (q)	Overall response ha^{-1} (q)	Response Kg^{-1} phosphate
D1	P0	1.607	1.591	–	–
	P1	2.339	2.386	0.795	0.032
	P2	2.775	2.728	0.342	0.014
	P3	2.603	2.618	(-) 0.109	(-) 0.004
Mean		2.331	2.331		
D2	P0	1.593	1.580	–	–
	P1	2.246	2.257	0.668	0.027
	P2	2.546	2.535	0.278	0.011
	P3	2.422	2.426	(-) 0.109	(-) 0.004
Mean		2.201	2.201		
D3	P0	1.119	1.116	–	–
	P1	1.424	1.433	0.317	0.013
	P2	1.612	1.603	0.170	0.007
	P3	1.624	1.627	0.024	0.0001
Mean		1.444	1.444		
D4	P0	0.706	0.697	–	–
	P1	0.921	0.940	0.243	0.010
	P2	1.071	1.056	0.116	0.0023
	P3	1.040	1.044	(-) 0.012	(-) 0.00016
Mean		0.934	0.934		

Table 42 : Factor product relationship for phosphorus at D1 treatment

Physical relationship						Economic relationship				
P_2O_5 (Units)	P_2O_5 (input 'X') ($kg\ ha^{-1}$)	$\hat{Y}$ Total product ($Q\ ha^{-1}$)	Marginal input ($kg\ ha^{-1}$)	Marginal product ($Q\ ha^{-1}$)	Quantity of response over base level ($Q\ ha^{-1}$)	Marginal cost of marginal input (Rs. np)	Marginal return of marginal product (Rs. np)	Value of response over base level (Rs. np)	Total cost of inputs (Rs. np)	Net revenue or profit over base level (Rs. np)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) (9-10)
0	0	1.591	--	--	--	--	--	--	--	--
1	25	2.386	25	0.795	0.795	396.75	3577.50	3577.50	396.50	3180.75
2	50	2.728	25	0.342	1.137	396.75	1539.0	5116.50	793.50	4323.0
'X' opt.										
2.062	51.56	2.734	1.56	0.006	1.143	24.76	27.00	5143.50	818.26	4325.24
'X' max.										
2.257	56.43	2.743	4.87	0.009	1.152	77.29	40.50	5184.00	895.55	4288.45
3	75	2.618	18.57	(-) 0.125	1.027	294.70	(-) 562.50	4621.50	1190.25	3431.25

Calculated on the basis of predicted yields

seed yield predicted at maxmum input level. The fertilizer dose thus proved to be optimum for potential seed production.

It follows from the data presented in Table 43 and depicted in Fig. 15 (b) that, at second sowing optimum input level of P_2O_5 found to be 49.77 kg ha^{-1} to predict a seed yield of 2.535 q as against maximum input level of 55.43 kg P_2O_5, wherein predicted yield was 2.544 q ha^{-1}. The predicted yield thereafter decreased drastically with increase in P_2O_5 dose.

Regarding third sowing, data presented in Table 44 and depicted in Fig. 15 (c) exhibited that, optimum and maximum input levels of P_2O_5 were 51.53 and 66.58 kg ha^{-1} to predict a seed yield of 1.609 and 1.635 q, respectively.

Optimum and maximum input levels computed for last sowing are presented in Table 45 and depicted in Fig. 15 (d). It was noted that, a dose of 42.91 kg P_2O_5 ha^{-1} was found to be optimum and predicted a yield of 1.036 q ha^{-1} as against maximum of 1.066 q ha^{-1} predicted at maximum input level (60.22 kg ha^{-1}).

The foregoing data revealed that, optimum input levels of P_2O_5 proved to be economical as they have given maximum net profit on the basis of predicted yields.

Response of K_2O was found to be non significant throughout the investigation. Seed yield at all levels of with and without K_2O were similar to one another. Similarly, none of the interactions with K_2O indicated significant variation. The optimum input level for K_2O therefore could not be worked out.

Table 43 : Factor product relationship for phosphorus at D2 treatment

Physical relationship						Economic relationship				
P_2O_5 (Units)	P_2O_5 (input 'X') (kg ha^{-1})	$\hat{Y}$ Total product (Q ha^{-1})	Marginal input (kg ha^{-1})	Marginal product (Q ha^{-1})	Quantity of response over base level (Q ha^{-1})	Marginal cost of marginal input (Rs. np)	Marginal return of marginal product (Rs. np)	Value of response over base level (Rs. np)	Total cost of inputs (Rs. np)	Net revenue or profit over base level (Rs. np)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) (9-10)
0	0	1.589	--	--	--	--	--	--	--	--
1	25	2.257	25.00	0.668	0.668	396.75	3006.00	3006.00	396.75	2609.25
'X' opt.										
1.991	49.77	2.535	24.77	0.278	0.946	393.10	1251.00	4257.00	789.85	3467.15
2	50	2.535	0.23	0.000	0.946	3.65	0.00	4257.00	793.50	3463.50
'X' max.										
2.217	55.43	2.544	5.43	0.009	0.955	86.17	40.50	4297.50	879.67	3417.83
3	75	2.426	19.57	(-) 0.118	0.837	310.58	(-) 531.00	3766.50	1190.25	2576.25

Calculated on the basis of predicted yields

Table 44 : Factor product relationship for phosphorus at D3 treatment

	Physical relationship				Economic relationship					
P_2O_5 (Units)	P_2O_5 (input 'X') (kg ha^{-1})	$\hat{Y}$ Total product (Q ha^{-1})	Marginal input (kg ha^{-1})	Marginal product (Q ha^{-1})	Quantity of response over base level (Q ha^{-1})	Marginal cost of marginal input (Rs. np)	Marginal return of marginal product (Rs. np)	Value of response over base level (Rs. np)	Total cost of inputs (Rs. np)	Net revenue or profit over base level (Rs. np)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) (9-10)
0	0	1.116	--	--	--	--	--	--	--	--
1	25	1.433	25	0.317	0.317	396.75	1426.50	1426.50	396.75	1029.75
2	50	1.603	25	0.170	0.487	396.75	765.00	2191.50	793.50	1398.00
'X' opt.										
2.061	51.53	1.609	1.53	0.006	0.493	24.20	27.00	2218.50	817.78	1400.72
'X' max.										
2.663	66.58	1.635	15.05	0.026	0.519	238.84	117.00	2335.50	1056.62	1278.88
3	75	1.627	8.42	(-) 0.008	0.511	133.71	36.00	2299.50	1190.25	1109.25

Calculated on the basis of predicted yields

Table 45 : Factor product relationship for phosphorus at D4 treatment

Physical relationship						Economic relationship				
P_2O_5 (Units)	P_2O_5 (input 'X') (kg ha^{-1})	$\hat{Y}$ Total product (Q ha^{-1})	Marginal input (kg ha^{-1})	Marginal product (Q ha^{-1})	Quantity of response over base level (Q ha^{-1})	Marginal cost of marginal input (Rs. np)	Marginal return of marginal product (Rs. np)	Value of response over base level (Rs. np)	Total cost of inputs (Rs. np)	Net revenue or profit over base level (Rs. np)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) (9-10)
0	0	0697	--	--	--	--	--	--	--	--
1	25	0.940	25	0.243	0.243	396.75	1093.50	1093.50	396.75	696.75
'X' opt.										
1.725	42.91	1.036	17.91	0.096	0.339	284.23	432.00	1525.50	680.98	844.52
2	50	1.056	7.09	0.020	0.359	112.52	90.00	1615.50	793.50	822.00
'X' max										
2.402	60.22	1.067	10.22	0.011	0.370	162.19	49.50	1665.00	955.69	709.31
3	75	1.044	14.78	(-) 0.023	0.347	234.56	(-) 103.50	1588.50	1190.25	398.25

Calculated on the basis of predicted yields

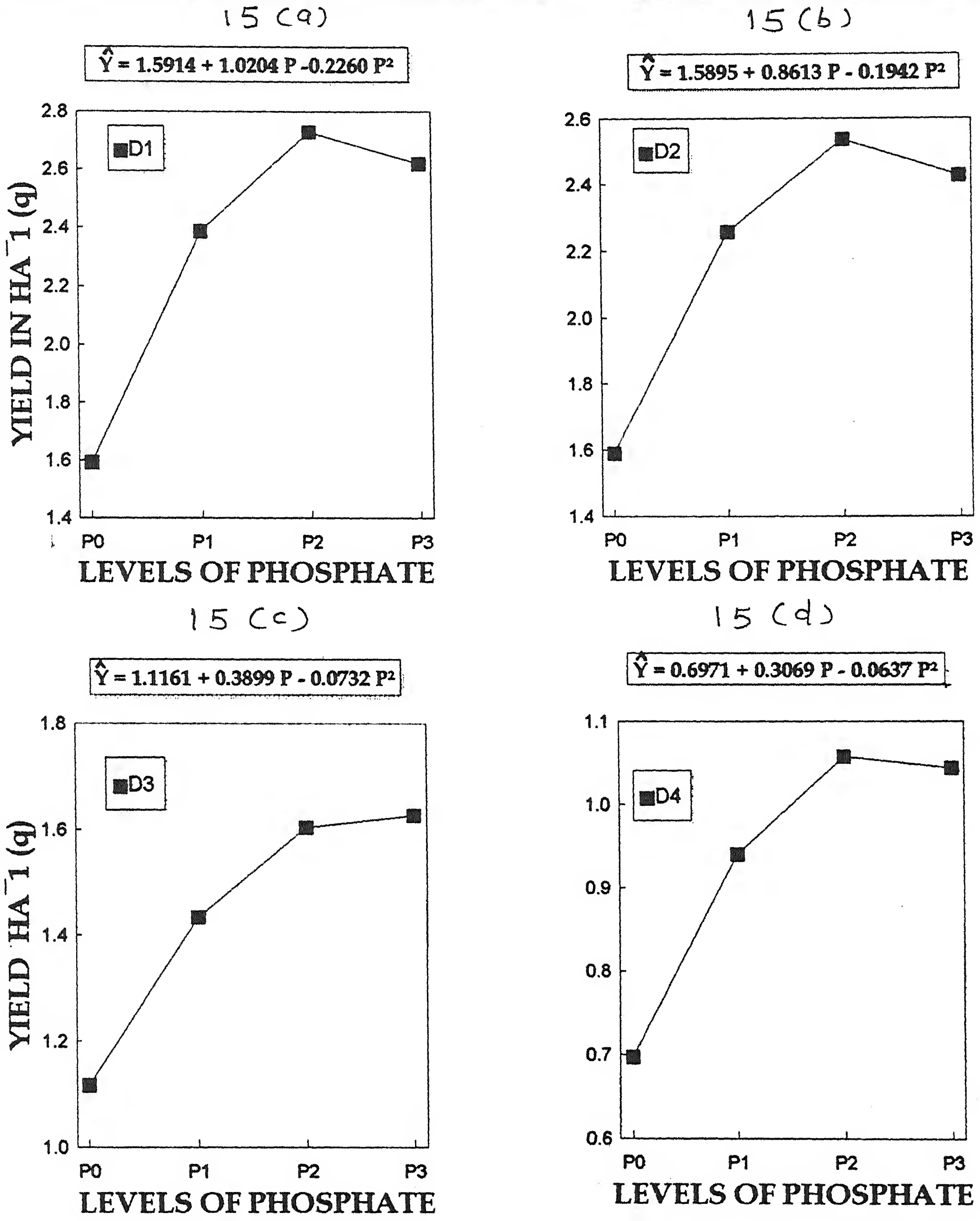


FIG.15: PREDICTED YIELD AS INFLUENCED BY VARIOUS PHOSPHATE LEVELS AT DIFFERENT SOWING TREATMENTS.

4.9 Economics of seed production

4.9.1 Monetary return and net profit

Data regarding monetary return and net profit ha^{-1} computed (on the basis of actual yield) for individual treatment considering the expenditure incurred towads each treatment are presented in Table 46,47 and 48.

Effect of sowing

Data presented in Table 46 revealed that, gross monetary return and net profit/loss obtained during 1994-95 and 1995-96 showed great variation.

In 1994-95, first sowing gave maximum gross return of Rs. 15844.50 ha^{-1} with a net profit of Rs. 2392.01 ha^{-1} at cost 'A'. Gross monetary return ha^{-1} (Rs. 14940.00), net profit ha^{-1} (Rs. 2081.11) was slightly decreased in second sowing than first at cost 'A'. Beyond this date there was great reduction in gross monetary return ha^{-1} as well as net profit ha^{-1} which was Rs. 8914.50 and Rs. 210.81 respectively in third sowing at the same cost. However, last sowing was most uneconomical which showed net loss of Rs. 2250.09 ha^{-1} at cost 'A'. Net return $rupee^{-1}$ investment also appeared in the same order which was more in first sowing (1.18) followed by second (1.16), third (1.02) and towards loss in the last sowing (0.71). At cost 'B' there was throughout loss in all sowings.

During 1995-96 as well as in pooled data none of the treatment proved profitable.

Table 46 : Monetary return and gross expenditure (Rs ha^{-1}), net profit (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by various treatments in seed production of *S. hamata* (cv. Verano)

Treatments	Gross monetary return (Rs ha^{-1}) (seed)			Gross expenditure 1994-95 (Rs ha^{-1})				
				Land prep., sowing seed, ferti., harvesting processing etc.	int. on working capital	Cost 'A' (4+5)	Land rent	Cost 'B' (6+7)
Sowing time	94-95	95-96	Mean					
	1	2	3	4	5	6	7	8
D1	158440.50	5139.00	10491.75	12691.03	761.46	13452.49	2640.75	16093.24
D2	14940.00	4878.00	9909.00	12131.03	727.86	12858.89	2490.00	15348.89
D3	8914.50	4090.50	6502.50	8211.03	492.66	8703.69	1485.75	10189.44
D4	5436.00	2970.00	4203.00	7251.03	435.06	7686.09	906.00	8592.09

Sowing time	Gross expenditure 1995 - 96 (Rs ha^{-1})					Gross expenditure (Rs ha^{-1}) Average of 94 - 95 & 95 - 96		Net profit at cost 'A'		
	Land prep., sowing seed, ferti., harvesting processing etc.	int. on working capital	Cost 'A' (9+10)	Land rent	Cost 'B' (11+12)	At Cost 'A'	At Cost 'B'	94-95	95-96	mean
	9	10	11	12	13	14	15	16	17	18
D1	11255.07	675.30	11930.37	856.50	12786.87	12691.43	14440.05	2392.01	(-) 6791.37	(-) 2199.68
D2	10295.07	617.70	10912.77	813.00	11725.77	11885.83	13537.33	2081.11	(-) 6034.77	(-) 1976.83
D3	8495.07	509.70	9004.77	681.75	9686.52	8854.23	9937.98	210.81	(-) 4914.27	(-) 2351.73
D4	8375.07	502.50	8877.57	495.00	9372.57	8281.83	8982.33	(-) 2250.09	(-) 5907.57	(-) 4078.83

Sowing time	Net profit at cost 'B'			B. C. ratio (Net return rupee^{-1} investment)					
				At cost 'A'			At cost 'B'		
	94 - 95	95-96	Mean	94 - 95	95 - 96	Mean	94 - 95	95 - 96	Mean
	19	20	21	22	23	24	25	26	27
D1	(-) 248.74	(-) 7647.87	(-) 3948.30	1.18	0.43	0.82	0.98	0.40	0.72
D2	(-) 408.89	(-) 6847.77	(-) 3638.33	1.16	0.45	0.83	0.97	0.42	0.73
D3	(-) 1274.94	(-) 5596.02	(-) 3435.48	1.02	0.45	0.73	0.87	0.42	0.67
D4	(-) 3156.09	(-) 6402.57	(-) 4779.33	0.71	0.33	0.51	0.33	0.32	0.47

Table 47: Monetary return and gross expenditure (Rs ha^{-1}), net profit (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by various treatments in seed production of *S. hamata* (cv. Verano)

Treatments	Gross monetary return (Rs ha^{-1}) (seed)			Gross expenditure 94-95 (Rs ha^{-1})				
				Land prep., sowing seed, ferti., harvesting processing etc.	int. on working capital	Cost 'A' (4+5)	Land rent	Cost 'B' (6+7)
Levels of P_2O_5	94-95	95-96	Mean					
	1	2	3	4	5	6	7	8
P0	8370.00	2938.50	5654.25	8855.96	531.35	9387.31	1395.00	10782.31
P1	11362.50	4234.50	7798.50	9252.71	555.16	9807.87	1893.75	11701.62
P2	12964.50	5049.00	9006.75	9649.46	578.96	10228.42	2160.75	12389.17
P3	12438.00	4860.00	8649.00	10046.21	602.77	10648.98	2073.00	12721.98

Treatments	Gross expenditure 95 - 96 (Rs ha^{-1})					Gross expenditure (Rs ha^{-1}) Average of 94 - 95 & 95 - 96		Net profit at cost 'A'		
	Land prep., sowing seed, ferti., harvesting Processing etc.	int. on working capital	Cost 'A' (9+10)	Land rent	Cost 'B' (11+12)	At Cost 'A'	At Cost 'B'	94-95	95-96	mean
	9	10	11	12	13	14	15	16	17	18
P0	8290.00	497.40	8787.40	489.75	9277.15	9087.35	10029.73	(-) 1017.73	(-) 5848.90	(-) 3433.10
P1	8686.75	521.20	9207.95	705.75	9913.70	9507.91	10807.66	1554.63	(-) 4973.45	(-) 1709.41
P2	9083.50	545.01	9628.51	841.50	10470.01	9928.46	1429.59	2736.08	(-) 4579.51	(-) 921.71
P3	9480.25	568.81	10049.06	810.00	10859.06	10349.02	11790.52	1789.02	(-) 5189.06	(-) 1700.02

Treatments	Net profit at cost 'B'			B. C. ratio (Net return rupee^{-1} investment)					
				At cost 'A'			At cost 'B'		
	94 - 95	95-96	Mean	94 - 95	95 - 96	Mean	94 - 95	95 - 96	Mean
	19	20	21	22	23	24	25	26	27
P0	(-) 2412.31	(-) 6338.65	(-) 4375.48	0.89	0.33	0.62	0.77	0.31	0.56
P1	(-) 339.12	(-) 5679.20	(-) 3009.16	1.16	0.46	0.82	0.97	0.43	0.72
P2	(-) 575.33	(-) 5421.01	(-) 2422.84	1.27	0.52	0.91	1.04	0.48	0.79
P3	(-) 283.98	(-) 5999.06	(-) 3141.52	1.17	0.48	0.83	0.98	0.45	0.73

Table 48: Monetary return and gross expenditure (Rs ha^{-1}), net profit (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by various treatments in seed production of *S. hamata* (cv. Verano)

Treatments	Gross monetary return (Rs ha^{-1}) (seed)			Gross expenditure 94-95 (Rs ha^{-1})				
				Land prep., sowing seed, ferti., harvesting processing etc.	int. on working capital	Cost 'A' (4+5)	Land rent	Cost 'B' (6+7)
Levels of K_2O	94-95	95-96	Mean					
	1	2	3	4	5	6	7	8
K0	10885.50	4167.00	7526.25	8855.96	531.35	9387.31	1814.25	11201.56
K1	11313.00	4239.00	7776.00	9267.56	556.05	9823.61	1885.50	11709.11
K2	11349.00	4311.00	7830.00	9679.16	580.74	10259.90	1891.50	12151.40
K3	11587.50	4365.00	7976.25	10090.76	605.44	10696.20	1931.25	12627.45

Treatments	Gross expenditure 95 - 96 (Rs ha^{-1})					Gross expenditure (Rs ha^{-1}) Average of 94 - 95 & 95 - 96		Net profit at cost 'A'		
	Land prep., sowing seed, ferti., harvesting Processing etc.	int. on working capital	Cost 'A' (9+10)	Land rent	Cost 'B' (11+12)	At Cost 'A'	At Cost 'B'	94-95	95-96	mean
	9	10	11	12	13	14	15	16	17	18
K0	8290.00	497.40	8787.40	694.50	9481.90	9087.35	10341.73	1498.19	(-) 4620.40	(-) 1561.10
K1	8701.60	522.09	9223.69	706.50	9930.19	9523.65	10819.65	1489.39	(-) 4984.69	(-) 1747.65
K2	9113.20	546.79	9659.99	718.50	10378.49	9959.94	11264.94	1089.10	(-) 5348.99	(-) 2129.44
K3	9524.80	571.48	10096.28	727.50	10823.78	10396.24	11725.61	891.30	(-) 5731.28	(-) 2419.99

Treatments	Net profit at cost 'B'			B. C. ratio (Net return rupee^{-1} investment) At cost 'A'			At cost 'B'		
	94 - 95	95-96	Mean	94 - 95	95 - 96	Mean	94 - 95	95 - 96	Mean
	19	20	21	22	23	24	25	26	27
K0	(-) 316.06	(-) 5314.90	(-) 2815.48	1.16	0.47	0.83	0.97	0.44	0.73
K1	(-) 396.11	(-) 5691.19	(-) 3043.65	1.15	0.46	0.81	0.96	0.42	0.72
K2	(-) 802.40	(-) 6067.49	(-) 3434.95	1.10	0.44	0.78	0.93	0.41	0.69
K3	(-)1039.95	(-) 6458.78	(-) 3749.36	1.08	0.43	0.77	0.92	0.42	0.68

Effect of P_2O_5

It is apparent from the data presented in Table 47 that, during 1994-95, gross monetary return ha^{-1}.(Rs. 12964.50), net profit ha^{-1} (Rs. 2736.08) and net return $rupee^{-1}$ investment (1.27) at cost 'A' as well as at cost 'B' (net profit ha^{-1} Rs. 575.33 and net return $rupee^{-1}$ investment, 1.04) was maximum in P2 treatment.

In 1995-96 and in avarage of both years there was net loss at all levels of with and without P_2O_5, at cost 'A' as well as cost 'B' also.

Effect of K_2O

As observed from the data shown in Table 48 that, gross monetary return ha^{-1} found to be increased with increasing levels of K_2O in 1994-95. But net profit ha^{-1} and net return $rupee^{-1}$ investment was higher in unfertilized treatment (Rs. 1498.19 and 1.16) at cost 'A'. At cost 'B' all K_2O treatments, with and without application showed net loss.

During 1995-96 and in pooled data none of the treatments proved to be profitable neither at cost 'A' nor at cost 'B'.

Interaction

Sowing time x P_2O_5 levels

Data presented in Table 49 indicated that, at first sowing application of P_2O_5 at P2 level gave maximum gross monetary return (Rs. 18954.00 ha^{-1}) with a net profit of Rs. 5293.30 ha^{-1} at cost 'A' and Rs. 2134.30 at cost 'B' respectively in 1994-95. The net return $rupee^{-1}$ investment was also higher at this level at both costs (1.38 and 1.13).

Table 49 : Monetary return, Gross expenditure (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by Sowing time X levels of phosphate during 1994-95, 1995-96 and pooled at D1 treatment

Treatments	Gross Monetary return (Rs ha-1)		Gross expenditure (Rs ha-1)					Grosss expenditure (Rs ha-1) pooled				
	Seed	Mean	L.P., seed, sowing ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'	L.P., seed, sowing, ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'
1	2	3	4	5	6	7	8	9	10	11	12	13
P0	10854.00	7231.50	12093.96	725.63	12819.59	1809.00	14628.59	11375.98	682.55	12058.53	1205.25	13263.78
	(3609.00)		(10658.00)	(639.48)	(11297.48)	(601.50)	(11898.98)					
P1	15790.50	10525.50	12490.71	749.44	13240.15	2631.75	15871.90	11772.73	706.36	12479.09	1754.25	14233.34
	(5260.50)		(11054.75)	(663.28)	(11718.03)	(876.75)	(12594.78)					
P2	18954.00	12487.50	12887.46	773.24	13660.70	3159.00	16819.70	12169.48	730.16	12899.64	2081.25	14980.84
	(6025.50)		(11451.50)	(687.09)	(12138.59)	(1004.25)	(13142.84)					
P3	17770.50	11713.50	13284.21	797.05	14081.26	2961.75	17043.01	12566.23	753.97	13320.20	1952.25	15272.45
	(5656.50)		(11848.25)	(710.89)	(12559.40)	(942.75)	(13502.15)					

Net profit (Rs. ha^{-1})				B.C. ratio (Net return rupee^{-1} investment)			
At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)	At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)
14	15	16	17	18	19	20	21
(-) 1965.59	(-) 4827.03	(-) 3774.59	(-) 6032.28	0.84	0.60	0.74	0.54
(-) 7688.48		(-) 8289.98		(0.32)		(0.30)	
2550.35	(-) 1953.59	81.40	(-) 3626.44	1.19	0.84	0.99	0.74
(-) 6457.53		(-) 7334.28		(0.45)		(0.41)	
5293.30	(-) 409.89	2134.30	(-) 2491.52	1.38	0.97	1.13	0.83
(-) 6113.09		(-) 7117.34		(0.49)		(0.46)	
3689.24	(-) 1606.83	727.49	(-) 3559.08	1.26	0.88	1.04	0.77
(-) 6902.90		(-) 7845.65		(0.45)		(0.42)	

(Figures in parenthesis refers to the year 1995-96)

Table 50 : Monetary return, Gross expenditure (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by Sowing time X levels of phosphate during 1994-95, 1995-96 and pooled at D2 treatment

Treatments	Gross Monetary return (Rs ha-1)		Gross expenditure (Rs ha-1)					Grosss expenditure (Rs ha-1) pooled				
	Seed	Mean	L.P., seed, sowing ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'	L.P., seed, sowing, ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'
1	2	3	4	5	6	7	8	9	10	11	12	13
P0	11160.00 (3181.50)	7168.50	11533.96 (9698.00)	692.03 (581.88)	12225.99 (10279.88)	1860.00 (530.25)	14085.99 (10810.13)	10615.98	636.96	11252.93	1194.75	12447.68
P1	15480.00 (4743.00)	10107.00	11930.71 (10094.75)	(715.84) (605.68)	12646.55 (10700.43)	2580.00 (790.50)	15226.55 (11490.93)	11012.73	660.76	11673.49	1685.25	13358.74
P2	16951.50 (5962.50)	11457.00	12327.46 (10491.50)	739.64 (629.49)	13067.10 (11120.99)	2825.25 (993.75)	15892.35 (12114.74)	11409.48	684.56	12094.04	1909.50	14003.54
P3	16173.00 (5629.50)	10899.00	12724.21 (10888.25)	763.45 (653.29)	13487.66 (11541.54)	2696.50 (938.25)	16183.16 (12479.79)	11806.23	708.37	12514.60	1816.75	14331.35

Net profit (Rs ha^{-1})				B.C. ratio (Net return rupee^{-1} investment)			
At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)	At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)
14	15	16	17	18	19	20	21
(-) 1065.99 (-) 7098.38	(-) 4084.43	(-) 2925.99 (-) 7628.63	(-) 5279.18	0.91 (0.31)	0.63	0.79 (0.29)	0.57
2833.45 (-) 5957.43	(-) 1566.49	253.45 (-) 6747.93	(-) 3247.24	1.22 (0.22)	0.86	1.01 (0.41)	0.75
3884.40 (-) 5158.49	(-) 637.04	1059.15 (-) 6152.24	(-) 2546.54	1.30 (0.53)	0.95	1.07 (0.49)	0.82
2685.34 (-) 5912.04	(-) 1613.35	(-) 10.16 (-) 6850.29	(-) 3420.06	1.20 (0.49)	0.87	1.00 (0.45)	0.76

(Figures in parenthesis refers to the year 1995-96)

Table 51 : Monetary return, Gross expenditure (Rs ha^{-1}) and net return rupee^{-1} investment as influenced by Sowing time X levels of phosphate during 1994-95, 1995-96 and pooled at D3 treatment

Treatments	Gross Monetary return (Rs ha-1)		Gross expenditure (Rs ha-1)					Grosss expenditure (Rs ha-1) pooled				
	Seed	Mean	L.P., seed, sowing ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'	L.P., seed, sowing, ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'
1	2	3	4	5	6	7	8	9	10	11	12	13
P0	7254.00 (2821.50)	5035.50	7613.96 (7898.00)	456.83 (473.88)	8070.79 (8371.88)	1209.00 (470.25)	9279.79 (8842.13)	7755.98	465.35	8221.33	839.25	9060.58
P1	8932.50 (3883.50)	6408.00	8010.71 (8294.75)	480.64 (497.68)	8491.35 (8792.43)	1488.75 (647.25)	9980.10 (9439.68)	8152.73	489.16	8641.89	1068.00	9709.89
P2	9585.00 (4918.50)	7254.00	8407.46 (8691.50)	504.44 (521.49)	8911.90 (9212.99)	1597.50 (819.75)	10509.40 (10032.74)	8549.48	512.97	9062.45	1209.00	1027.45
P3	9886.50 (4734.00)	7308.00	8804.21 (9088.25)	528.25 (545.29)	9332.46 (9633.54)	1647.75 (789.00)	10980.21 (10422.54)	8946.23	536.77	9483.00	1218.00	10701.00

Net profit (Rs. ha^{-1})				B.C. ratio (Net return rupee^{-1} investment)			
At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)	At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)
14	15	16	17	18	19	20	21
(-) 816.79 (-) 5550.38	(-) 3183.58	(-) 2025.79 (-) 6020.63	(-) 4023.21	0.90 (0.34)	0.61	0.78 (0.32)	0.55
441.15 (-) 4908.93	(-) 2233.89	(-). 1047.60 (-) 5556.18	(-) 3301.89	1.05 (0.44)	0.74	0.89 (0.41)	0.66
673.10 (-) 4294.49	(-) 1810.69	(-) 924.40 (-) 5114.24	(-) 3019.32	1.07 (0.53)	0.80	0.91 (0.49)	0.70
554.04 (-) 4899.54	(-) 2172.75	(-) 1093.71 (-) 5688.54	(-) 3391.12	1.06 (0.49)	0.77	0.90 (0.45)	0.68

(Figures in parenthesis refers to the year 1995-96)

Table 52 : Monetary return, Gross expenditure (Rs ha^{-1}) and net return $rupee^{-1}$ investment as influenced by Sowing time X levels of phosphate during 1994-95, 1995-96 and pooled at D4 treatment

Treatments	Gross Monetary return (Rs ha-1)		Gross expenditure (Rs ha-1)					Grosss expenditure (Rs ha-1) pooled				
	Seed	Mean	L.P., seed, sowing ferti, harvesting processing etc.	Int. on working capital	Cost 'A'	Land rent	Cost 'B'	L.P., seed, sowing, ferti, harvesting processing etc.	Int. on working capital	Cost 'A	Land rent	Cost 'B'
1	2	3	4	5	6	7	8	9	10	11	12	13
P0	4216.50 (2137.50)	3177.00	6653.96 (7778.00)	399.23 (466.68)	7053.19 (8244.68)	702.75 (356.25)	7755.94 (8600.93)	7215.98	432.95	7648.93	529.50	8178.43
P1	5242.50 (3046.50)	4144.50	7050.71 (8174.75)	423.04 (490.48)	7473.75 (8665.23)	873.75 (507.45)	8347.50 (9172.68)	7612.73	456.76	8069.49	690.75	8760.24
P2	7263.00 (3285.00)	4819.50	7447.46 (8571.50)	446.84 (514.29)	7894.30 (9085.79)	1210.50 (547.50)	9104.80 (9633.29)	8009.48	480.56	8490.04	803.25	9293.29
P3	5917.50 (3415.50)	4680.00	7844.21 (8968.25)	470.65 (538.09)	8314.86 (9506.34)	986.25 (569.25)	9301.11 (10075.59)	8406.23	504.37	8910.60	780.00	9690.60

Net profit (Rs. ha^{-1})				B.C. ratio (Net return $rupee^{-1}$ investment)			
At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)	At Cost 'A'	Mean (Pooled)	At Cost 'B'	Mean (Pooled)
14	15	16	17	18	19	20	21
(-) 2836.69 (-) 6107.18	(-) 3471.93	(-) 3539.44 (-) 6463.43	(-) 5001.43	0.59 (0.26)	0.41	0.54 (0.25)	0.39
(-) 2231.25 (-) 5618.73	(-) 3924.99	(-) 3105.00 (-) 6126.18	(-) 4615.59	0.70 (0.35)	0.51	0.63 (0.33)	0.47
(-) 631.30 (-) 5800.79	(-) 3216.04	(-) 1841.80 (-) 6348.29	(-) 4095.04	0.92 (0.36)	0.57	0.80 (0.34)	0.52
(-) 2397.36 (-) 6090.84	(-) 4244.16	(-) 3383.61 (-) 6660.09	(-) 5021.85	0.71 (0.36)	0.52	0.64 (0.34)	0.48

(Figures in parenthesis refers to the year 1995-96)

At second sowing also, gross monetary return ha^{-1} (Rs. 16951.50), net profit ha^{-1} and net return $rupee^{-1}$ investment increased at cost 'A' (Rs. 3884.40 and 1.30), as well as at cost 'B' (Rs. 1059.15 and 1.07) respectively, when P_2O_5 was maintained at P2 level in 1994-95 (Table 50).

It was observed from the data presented in Table 51 that, each successive increase in P_2O_5 dose gross monetary return ha^{-1} increased at third sowing during 1994-95, but net profit (Rs. 673.10 ha^{-1}) and net return $rupee^{-1}$ investment (1.07) at cost 'A' was higher in P2 treatment. However at cost 'B' there was net loss.

Data in Table 52 indicated that, at last sowing gross monetary return ha^{-1} although was higher at P2 level, but it could not prove profitable during 1994-95.

Data further revealed that, during 1995-96 and when it was pooled there was net loss in all sowings and at all levels of P_2O_5 at cost 'A' as well as at cost 'B' also.

Overall it was observed that the best treatment combination amongst all, was found to be first sowing with P2 level of P_2O_5.

CHAPTER - V

DISCUSSION

DISCUSSION

The experiment "**Effect of sowing time and levels of phosphorus and potash on seed production in *Stylosanthes hamata* (L.) cv. Verano**" was conducted at Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi during Kharif 1994-95 and 1995-96 with the objective to assess the seed yield potential of the crop in relation to various sowing times and graded levels of phosphorus and potash. The results are discussed in this chapter, on the basis of which an attempt has been made to explain probable reasons of variations obtained due to different treatments.

5.1 Crop and season

The rainfall during 1994-95 may be categorised as adequately well distributed throughout the growth period and was 528.5 mm received in 37 rainy days, which was considered to be the less than the normal (958mm). The maximum and minimum temperatures during crop growth ranged between 18.6 to 34.2°C and 2.9 to 25.2°C, respectively. Both these factors appeared to have favoured crop growth sown during the last week of June and mid July.

The year 1995-96 had received total rainfall of 837.10

mm in 49 rainy days, which was close to the average rainfall of the region, but was erratic in distribution. Heavy rains received during the meteorological week 31 and 34 seems to have affected crop growth and flowering behaviour besides water logging. The maximum and minimum temperature ranged between 20.0 to 41.1°C and 5.1 to 30.7°C, which also varied from the normal temperature (5 to 33°C). All these factors and also overcroweded and unevenly distributed plant population in all the treatments attributed towards less seed production compared to that in the year 1994-95.

5.2 Effect of sowing

5.2.1 Plant population

The crop was sown at four different dates viz. 28th June, 13th July, 27th July and 13th August during 1994-95. During 1995-96, there was no sowing and it was allowed to establish through auto seeding from available soil seed reserves (bank) of the first year crop. Plant stand was maintained as such as observed naturally by thinning and gapfilling wherever possible to test the effects of various sowing treatments by way of existing soil seed pool.

The plant population showed significant variation due to sowing treatments at seedling as well as at harvest stage throughout the study. In 1994-95, significantly higher plant population was observed in 28th June (72500 ha^{-1}) and 13th July (72000 ha^{-1}) sowings and subsequently decreased with delay in sowing and was minimum in the last treatment (13th August), (Table 5). Higher soil temperature and better soil moisture due to better rainfall during sowing time in 1994-95 might have promoted better

germination and ultimately resulted into higher plant population in early sowings (28th June and 13th July). McKeon and Mott (1982) also suggested maximum soil temperature for softening of hard seed (50-55°C) in *S. hamata*. This was supported by Sharma (1985), who observed maximum germination in May sown *S. hamata* CPI 38842. Contrary to this low level of population in delayed sowings (27th July and 13th August) may be due to low soil temperature, which hampered seed germination adversely and reduced plant stand in these treatments. Similar results of reduction in plant population due to late sowing were published by various workers, Anonymous (1974) in *S. humilis*; Edye et. al. (1976) in *S. hamata* cv. Verano; Velayudhan et. al. (1977) in *S. humilis* established in *Sehima-Heteropogon* grassland; Anonymous (1985) in *S. hamata*; Anonymous (1992) in various *Stylosanthes* species.

In 1995-96, plant population was nearly eight times higher (28th June, 331000 ha^{-1} and 13th July, 319600 ha^{-1}) and indicated similar trend of first year. Survival rate of perennial plants ranged from 15 to 19% (Table 6) (Gutteridge, 1986) and only new seedlings were responsible to contribute the plant population. Observations made by Anonymous (1984 a), Sharma (1985) were also in the same line, where in population of perennial plants in *S. hamata* was reduced by 88.62 and 60.59% respectively after one year. Mortality of perennial plants might have been caused due to less clay content in soil (Clatworthy, 1974), low soil moisture (Brolmann, 1979) and high soil temperature during peak summer. Moreover, Gutteridge (1986) stated that, *S. hamata* cv. Verano absolutely acts as a weak biennial. Similarly, being an indeterminate plant the growth is continued during reproductive phase

(Wilaipon et. al., 1979). Flowering, seed setting and shading therefore are regular features of this crop. As the seed collection generally took place by sweeping the ground surface and soil seed reserves which is highly correlated with plant population (Anonymous, 1986), perhaps varied with various sowing treatments, which may be the cause of variation in plant population in the respective treatements. The length of growing season, amount of seed produced and nature of ground surface i.e. crevises, density of stubbles (Singh et. al., 1994) probably affected the seed recovery during 1994-95. The amount of seed pool may have resulted into overall increase in plant stand as reflected in various treatments. Decrease in plant population due to delay in sowing and increase in plant stand in subsequent year to the tune of six times was also reported by Rai and Patil (1984, 1985, 1986), Anonymous (1986) in *S. hamata*.

5.2.2 Plant growth

The plant height was observed to be significantly more in 28th June and 13th July sowings in 1994-95 and decreased thereafter with each delay in sowing. The decrease in plant height probably be due to availability of shorter growing season resulting into stunted growth and ultimately reduced the plant height to the extent of 17.73 cm plant^{-1} in 13th August sowing. Conversely the crop sown on 28th June and 13th July availed more growth degree days because of its longer duration. This perhaps helped in stem elongation in these treatments. In 1995-96, none of the treatments influenced plant height significantly but was comparatively higher in 28th June and 13th July sowings. This indicated that, competition amongst plants caused due to higher plant density might have reflected into higher vertical growth

in terms of plant height in both earlier sowings. As competition reduced the plant height found to be reduced in the late treatments. Thus, effect of growing season was more consistant during 1994-95. However, during 1995-96, plant density might have played a key role in vertical growth behaviour of the crop (Table 7).

During 1994-95, the stem diameter plant^{-1} significantly increased due to early sowings (after seedling stage) and reached to maximum in 28th june and 13th July as against minimum in the late treatments. However, during 1995-96, sowing treatment had no effect on stem diameter at all (Table 8). Number of branches plant^{-1} were also significantly higher, seedling stage onwards in both early sowings (28th june and 13th July) in 1994-95 and in the late treatment (13th August), which was at par with 27th July in 1995-96 (Table 9). The highest rate of increase in these growth attributes was observed to be upto 80% flowering stage.

Significant influence of various sowings was also recorded on leaf area plant^{-1}, which was significantly higher in 28th June and 13th July sowings at all stages during 1994-95. Hovever, during 1995-96 it showed significantly greater values in 13th August and 27th July sowings. In both the years, leaf area plant^{-1} attained maximum values at 80% flowering stage and decreased thereafter which can be attributed to shading of leaves (Table 10).

Leaf area index, which is a measure of spread of plant in relation to its density was also significantly higher in both earlier sowings done on 28th June and 13th July. Consecutive delay in sowing resulted significant

decrease in the LAI values at all stages. It was also observed that, throughout the study LAI was maximum at 80% flowering stage (Table 11). This is in tune with the findings reported by Wilaipon et. al. (1979).

The dry matter accumulation plant^{-1} significantly increased upto 80% flowering stage and decreased latteron. This may be due to fall of leaves and balls including seeds. The treatment differences in plant growth, diameter of stem, number of branches, and leaf area plant^{-1} were fully reflected in dry matter accumulation, which was significantly higher in 28th June and 13th July sowings at all stages during 1994-95. Subsequent delay in sowing showed significant decrease in dry matter accumulation which was to the extent of 55% in 13th August sowing over that in 28th June. Shelton and Humphreys (1975) also reported similar observations. During 1995-96, dry matter accumulation was found to be enhanced in the late treatments as recorded at 80% flowering and harvest and was maximum in 13th August and 27th July sowings (Table 12). It was also obsrved that, dry matter accumulation was two and half times higher in 1994-95 compared to that in 1995-96 at the highest stage of accumulation. Higher plant density in 1995-96 in all treatments and the competition caused amongst plants might have reflected into slow growth, which inturn resulted into lower dry matter accumulation. This is in conformity with the results reported by Pongskul et. al. (1982), Brolmann and Boaman (1991).

The rate of growth as exhibited as RGR of dry matter g g^{-1} day^{-1} was proportionately increased due to delay in sowing. It was maximum for the period of seedling to 80% flowering stage, which was due to the fact of increase in the rate of plant height, stem diameter, leaf area and

dry matter accumulation between this period. Observations made by Wilaipon <u>et</u>. <u>al</u>. (1979) and Rai (1989 a) in *S. hamata* were also in the same line. For latter growing period i.e. from 80 % flowering to harvest, RGR was observed to be negative because of litter fall and balls including seeds (Table 13)..

While going through the foregoing discussion, trend of results in respect of plant height, stem diameter, number of branches, leaf areas and dry matter accumulation plant^{-1} was observed to be almost in a reverse manner during both the years of experimentation. All these attributes showed higher values in 28th June and 13th July sowings during 1994-95, which might be due to availability of more growth period, favourable temperature (32.5 to 32.9°C) and soil moisture. Cameron (1967) also suggested that, dry matter accumulatioin inhibited below 30°C day temperature. Whiteman (1968) also considered 80°F and 91°F day temperature as optimum for better crop growth. similarly, Skerman and Humphreys (1973) recorded maximum dry matter accumulation at 31/17°C day/night temperature. The present findings are in agreement of these results. Conversely the lower values in these attributes with delayed sowing might be due to decrease in growth degree days and temperature: besides depletion in soil moisture at grand growth period. The observations made by Luiz <u>et</u>. <u>al</u>. (1989) in *S. hamata* and *S. guianensis* were in tune with the present study. During 1995-96, competition amongst plants caused due to thick population affected photosynthetic activity, restricted crop growth and resulted into lower stem diameter, number of branches, leaf area and dry matter accumulation in both earlier sowings. Cohen (1971) made similar observations and stated that, competition between

plants favours inefficient mode of growth and canopy structure. As competition reduced, growth was accelerated and attained maximum in the late sowing treatments (13^{th} August and 27^{th} July).

Inspite of the variations recorded in individual year, pooled results clearly indicated superiority of 28^{th} June sowing, which was equal in effects with 13^{th} July amongst all treatments. The plant height, stem diameter, number of branches, leaf area and dry matter accumulation plant^{-1} was significantly more in both these sowings.

5.2.3 Nodulation and root growth

During 1994-95, the number of nodules and nodule dry matter plant^{-1} was significantly more in early sown (28^{th} June and 13^{th} July) crop at all stages of growth. On the contrary, during 1995-96 the same were significantly more in the late sown (13^{th} August and 27^{th} July) ones, but seedling stage onwards. It was also observed that, nodule growth was slow in the beginning which hastened with the age of crop and attained maximum at 90^{th} day but declined thereafter (Table 14 to 19). This is in tune with the findings reported by Oke (1967) in *S. gracilis;* Baldos and Javier (1979), Lopez et. al. (1984); Rai (1989 b) in *S. guianensis, S. hamata, S. humilis, S. scabra* and *S. viscosa.*

Beneficial effects of early sowings were also recorded on root dry matter plant^{-1} in 1994-95. Both earliest sowings (28^{th} June and 13^{th} July) produced significantly more root dry matter than that in the latter treatments. In 1995-96, the trend of results was reverse and it increased in the late treatments of 13^{th} August and 27^{th} July (Table 20 to 22).

Results in respect of nodulation, nodule dry matter and root dry matter plant^{-1} suggests that, maximum period availed for growth and relatively better soil moisture might have enhanced root growth and thereby nodulation and nodule dry matter in both early treatments in 1994-95. In 1995-96, perhaps dense population and competition amongst plants for moisture and nutrients, most probably affected root and nodulation behaviour in 28th June and 13th July sowings.

Pooled results almost revealed significant improvement in nodule number, its resultant dry matter and root dry matter plant^{-1} in 28th June and 13th July sowings to the tune of 41.53 and 40.20%, 23.78 and 22.63%, and 49.16 and 46.24% respectively over 13th August sowing.

5.2.4 Floral initiation and maturity

Sowing treatments found to influenced floral initiation(FI) and maturity considerably. Crop sown on 28th June (51.79 days) took longer period for FI, which reduced subsequently and was minimum in both latter sowings (27th July and 13th August). This is in conformity with the findings reported by Wilaipon et. al. (1979), Tudsri et. al. (1989) in *S. hamata* cv. Verano under normal sowing. The reduction in FI period in late sown crop might be due to warm temperature (32.0 to 34.9^{0}C) and depletion in soil moisture during vegetative phase, which hastened floral initiation. The observations made by Ive and Fisher (1974), Fisher and Campbell (1977) in *S. humilis,* Ison and Humphreys (1984) in *S. guianensis* cv. Endeavour and Schofield were similar in confirmation with the present study. During 1995-96, floral initiation was not affected because of emergence of plants

simultaneously after monsoon breakup in all treatments. DeAndrade (1983) made similar observations. In pooled also, minimum period for FI was recorded in both latter sowings (13th August and 27th July) and maximum in 28th June sowing (Table 23).

Crop maturity was significantly affected by sowing treatments during 1994-95 and minimm period was recorded in 13th August sown crop (142.62 days), as against maximum in 28th June (187.09 days). It is a well established fact that, moisture stress shortens the reproductive phase and hastens maturity. This may be the reason for shorter maturity period recorded in late sown crop. In 1995-96, maturity period was more or less similar in all the treatments. This was due to the fact that, germination of seed took place through the soil seed reserves more or less at the same time which did not resulted into variation in crop maturity. Pooled results indicated the trend of initial year (table 24).

5.2.5 yield contributory characters and yield

Inflorescence density was positively related to earliness in sowing and found significantly higher in both former treatments (28th June and 13th July) during 1994-95. Higher growth period availed by the crop and favourable temperature conditions increased ball prodution in these treatments.Observations made by Skerman and Humphreys (1973), Schoonovar and Humphreys (1974) in *S. humilis* were also in the same line. On the contrary, during 1995-96, number of balls plant^{-1} were more in 13th August and 27th July treatments. It is stated earlier while discussing various parameters that, delay in sowing resulted less plant population and thereby less

competition amongst plants for availability of nutrients and moisture which might have enhanced ball production in the delayed treatements. However, both earlier treatments (28th June and 13th July) maintained their superiority over delayed treatments on pooled basis. (Table 25).

Significant influence of various sowings was not recorded on number of seeds ball^{-1} , but weight of seeds ball^{-1} was significantly increased when sowing was made on 28th June and 13th July in 1994-95. Temperature conditions have positive effect on number of florets and seed weight, which was maximm in early sowings and less due to inflorescence differentiation in late sowings. This is in agreement with the findings reported by Skerman and Humphreys (1973), (1975) in *S. humilis,* who observed highest seed weight at 24°C nacto temperature and inflorescence differentiation at 17/10°C.During 1995-96, because of similar temperature conditions sowing treatments had no effect on these characters. Significantly higher weight of seeds ball^{-1} was observed in both earlier sowings in pooled results.(Table26).

The seed yield plant^{-1} was found to be significantly increased due to early sowings in 1994-95 and due to late sowings during 1995-96.Crop sown on 28th June and 13th July yielded significantly higher seed and then decreased due to late sowing during1994-95. More number of seeds balls^{-1} and their resultant weight, similarly more number of balls plant^{-1} and their resultant weight collectively increased the yield plant^{-1} in early sown treatments.The increase in seed yield, in 13th August and 27th July sowings during 1995-96 was due to imporvement inall these yield attributes in these treatments which resulted into higher seed production.But on pooled basis both earlier sowings proved better than both the late sowings. (Table27).

Although, number of seeds ball^{-1} , weight of seeds ball^{-1} ,number of balls plant^{-1} and weight of balls plant^{-1} showed opposite trend of results during the two respective years, the seed yield ha^{-1}, however, indicated consistant trend of effects and almost showed increase with early sowings. During both the years, seed yield ha^{-1} was significantly higher in both earliest sowings (28th June and 13th July), which were equally better than others.The delay in sowing had drastic reduction in seed yield (27th July) and was lowest when the sowing was highly delayed as in 13th August (Table 28).Seed yield unit^{-1} area is a resultant of seed yield plant^{-1} and the plant density ha^{-1} .Higher plant populatioin, stronger yield attributes and theirby more seed yield plant^{-1} , reflected towards higher seed production in 28th and 13th July sowings during 1994-95. During 1995-96, though all the yield attributes recorded higher values in delayed treatments, but because of maximum plant population, seed yield was significantly more in both early sowings. Over all, there was38% and 60% decrease in seed yield due to 27th July and 13th August sowings, respectively. The observations made by Moolsiri et. al. (1980) are in agreement with the present study. Higher seed yield from early flowering lines was also reported by Cameron and Mannetje (1977) in *S. humilis*. Reduction in seed yield due to late sowings and increase in seed yield due to early sowings was also observed by Cameron (1967) is *S. hamata;* Fisher and Champ bell (1977),Tomar and Dixit (1988) in *S. humilis*. It was obviously noted that, inspite of higher plant population during 1995-96,seedyield ha^{-1} was quite low than the first year. DeAndrade et. al. (1983) made similar observations in this crop. English and Hopkinson (1985) therefore might have stated that, for higher seed production *S. hamata* cv. Verano should be grown as an

annual crop. The present authors are also of the same opinion.

Beneficial effects of early sowings were also recorded on straw production ha^{-1} throughout the study. There was significantly maximum straw yield in 28th June sowing (46.75 q ha^{-1}). Straw yield in 13th July sowing (44.31 q ha^{-1}) was also significantly higher than 27th July and 13th August, but was similar to that in 28th June sowing. Subsequently, each successive delay, as in 27th July and 13th August sowings straw yield decreased significantly to the tune of 33 and 30% as well as 50 and 53% over those in 28th June and 13th July, respectively (Table29). Significantly higher plant population and higher vegetative growth (number of branches and dry matter accumulation plant^{-1}) appeared to have contributed towards higher straw yield in both early treatments during 1994-95. During 1995-96 also the straw yield was significantly more in both earlier treatments.This increease in straw yield can be safely attributed to higher plant population in these treatments. Higher straw from early sown crop was also reported by Pongskul et. al. (1982) in *S. hamata* cv. Verano, Anonymous (1986), (1992); Williams et. al. (1995) in *S guianensis*. Lower yield due to late sowing was observed by McIvor (1983).

Harvest index, a ratio of economical and biological yield expressed interms of percentage, was found to be increased with lateness in sowing and was significantly maximum in 13th August sowing (Table 29). This observation is in concurrene with those reported by Kowithayekorn and Moolsiri (1980) in *S. scabra* cv. Seca ; Molsiri et. al. (1980) in *S. hamata* cv. Verano.

5.2.6 Quality studies

Significant influence of early sowings was recorded on test weight, which was higher in 28th June and 13th July during 1994-95. Temperature conditions at the time of seed setting and ripening (31.3/24.2 to 32.9/13.0°C in met. week 36 to 44) favoured increase in test weight in these treatments. This is in conformity with the findings reported by Skerman and Humphreys (1973). During 1995-96,treatment effects were non significant, . But pooled results indicated higher test weight in 28th June sowng, which was similar to 13th July.(Table 30). Protein contents were not significantly affected due to various sowings throughout the study. Non influence of early sowing on C.P. contents was also reported by Gronowicz et. al. (1987) in field pea. Laboratory studies indicated significant influence of late sowings on seed germination during 1994-95. The seed obtained from 13th August sowing followed by 27th July exhibited significantly higher germination compared to early sown crop. But seeds from both these treatments were equal in germination. In this context, Argel and Humphrey s (1984) stated that, seed formed at high temperature contained more lignin and hemicellulose. Further they stated that,hard seededness (<97%) occurs when mean temperature during seed formation period is above 24°C and below 24°C it decreases rapidly. The seed coat of hard seed exhibited more regular and organized structure and more evenly reticulated surface than soft seed. In the present study, temperature during seed formation in 28th June and 13th July sown crop was 31.3 to 32.92°C. (in met. week 36 to 44) which might have favoured producing hard seed, impermeable to water and thereby showed reduced germination compared to those seeds obtained from the late sowings

(because of soft seed produced). During 1995-96, there was no significant influence of various sowings on seed germination because of similar temperature conditions. On pooled basis germination was significantly higher in seed obtained from 13th August and 27th July sowings. (Table 32).

5.2.7 Nutrient contents and uptake

The N, P, K contents in plant were significantly increased due to early sowing and were maximm in 28th June which was at par with 13th July at 80% flowering stage in 1994-95. Favourable conditions, better plant growth and more nutrient absorption due to better root growth, increased the concentration of these nutrients in early treatments. During 1995-96, sowing treatment had no effect on nutrient concentrations though were relatively increased in 13th August perhaps due to lower plant population, less competition and thereby better plant growth . Pooled results indicated significantly higher N concenration in 28th June, thqn 13th August (Table 33). At harvest stage nutrient concentration remain unaffected (Table 34) because of shading of above ground biomass (leaves, balls including seeds) in terms of top growth, which is supposed to be rich in nutrients. Robinson and Jones (1972) reported similar findings. It was also noted that,nutrient concentration decreased with the age of crop, which might be due to dilution effect.

The total uptake of N, P, K was significantly improved due to early sowing and was higher in 28th June and 13th July (Table 35). Nutrient uptake is a resultant of plant population unit^{-1} area, dry matter accumulation plant^{-1} and nutrient concentration in plant tissues. All these characters cumulatively conributed towards higher uptake in these treatments.It was also

observed that,total uptake was more during1995-96 as compared to 1994-95.This might be due to tremendous increase in the plant population resulting into more uptake during this year.

5.2.8 Residual soil fertility

Residual soil fertility in respect of N, P and K did not show noticeable variation due to various sowings.Available nitrogen was relatively increased due to early sowings and P and K with lateness in sowing (Table 36).This increase in nitrogen in early sowing may be attributed to higher plant density and more nodulation resulting into higher nitrogen fixation. In this context Butler and Bathurst (1956) reported that the nitrogen in soil depends upon the density of crop.Similarly it is also a well known fact that, soil fertility mostly depends upon the addtion and removal of nutrients by the crop.Therefore the uptake of N was though higher in early sowings, the addition of N was also higher through nitrogen fixation, which resulted into higeher available N. However, it was not happened with P and K, which were increased in the late treatments on account of less uptake because of low plant population.

5.2.9 Moisture retention

Soil moisture did not present a regular pattern at sowing time as well as at seedling stage, but found to be varied with amount of rainfall received in 1994-95. At 80% flowering also decrease in soil moisture in the late sown treatment was the resultant of variation in rainfall and cessation of rains. At harvest stage however, soil moisture increased with lateness in sowings, probably due to less plant population and thereby less utilization

of moisture by the crop.In 1995-96, there was consistant trend of increase in soil moisture with delayed sowing at 80% flowering and at harvest stage, which was also due to similar reason (Table 37, 38 and 39).

In the light of above discussion, sowing dates of 28th June and 13th July were similar in growth performance, root and nodulation behaviour, yield attributes, nutrient contents and their uptake throughout the investigation, except some of the observations viz.flower initiation, maturity and N, P,K uptake during 1994-95. During 1995-96, late treatments of 13th August and 27th July recorded significant increase in respect of growth, root and nodulation, yield attributes over other sowings, but found to be statistically at par with each other. However, on the basis of pooled results, it can be concluded that, both earlier sowings of 28th June and 13th July proved to be optimum for stylo seed production.

5.3 Effect of P_2O_5

Phosphorus is a constituent of nucleic acid, phospholipids, enzymes and has great importance in carbohydrate, fat metabolism, energy tranformation and respiration. It stimulates root development and increases number of tillers etc.

5.3.1 Plant population

Plant population ha^{-1} at seedling as well as at harvest was not affected by graded levels of P_2O_5 (Table 5) throughout the study. Several workers,Olsen and Moe (1972), Shaw (1978), Dance (1985) in *S. humilis,* Gilbert and Shaw (1980) in *S. humilis* cv. Paterson, *S. hamata*

cv. Verano and *S. scabra* cv. Fitzory; Singh (1984) in *S. hamata* cv. Verano; Mohamad Saleem and Von kaufimam (1986) in *S.guianensis* cv. Cook, *S. hamata* cv. Verano; Strickland and Greenfield (1988) in various *stylosanthes* species reported similar results.

5.3.2 Growth and its attributes

Plant height did not show significant variation due to graded levels of P_2O_5 at all stages throughout the experimentation (Table 7). This is in tune with the findings reported by Rai and Patil (1983) in *S. guianensis,* (1984) in *S. scabra;* Singh (1985) in *S. hamata* cv. Verano; Rai and Patil (1986) in *S. hamata*. Stem diameter plant^{-1} , number of branches plant^{-1} , leaf area plant^{-1} and dry matter accumulation plant $^{-1}$ were was significantly incresed due to P_2O_5, seedling stage onwards (Table 8 to 10 and 12). However, effect on LAI was consistant throughout all growth stages.With each progressive increase in P_2O_5, there was significant increase in stem diameter upto 50 kg application ha^{-1} recorded at maximum stage of growth(at harvest) (Table 11). The number of branches, were also significantly increased from 80% flowering stage onwards upto 50 kg P_2O_5 ha^1 , over lower levels.This was possibly be due to efficient utilization of moiture and optium um availability of nutrients, which resulted into more uptake of nitrogen, favouring more systhesis of nucleic acids and ultimately enhaning cell division with improving these characters.Significant influence of phosphate application on branches was also reported by Singh (1985), Khara et. al. (1990) in *S. hamata* cv. Verano. More branches and perhaps more leaves may account for significant increase in leaf area at 50 kg ha^1. Baldos and Javier (1979) reported identical findings in *S.humillis.* The dry matter accumulation plant^1 was found to be significantly

increased due to improvement in branches and more photosynthesising area at 50 kg P_2O_5 over its lower levels. The observations made by Singh (1985), Khara et. al. (1990) in *S.hamata* cv. Verano are also in agreement with the present study. The LAI followed similar pattern as that of leaf area except at seedling stage during 1994-95, where significant variation amongst all levels of with and without P_2O_5 was not visible. But in the subsequent year higher dose (75 kg ha^{1}) proved to be superior over unfertilized treatment at this stage,which might be due to residual P content in the soil.Similarly,the differences within highly fertilized treatments (50 and 75 kg ha^{-1}) in respect of all these growth atributes were not identified perhaps due to continous turn over of organic matter in soil by way of leaf fall. This might have helped in solubalization of insoluble P present in the soil and thereby enriching it with available phosphorus. This is why the crop may not responded at higher rate of application ((75 kg ha^{-1}).

The rate of dry matter accumlation recorded in terms of RGR was minimum when no fertilizer was applied. But it increased subsequently with addition of P_2O_5 (Table 13). The RGR found to be highest between seedling to 80% flowering stage. This increase in RGR atributed to increase in growth attributes such as plant height,stem diameter, number of branches and dry matter accumulation $plant^{1}$. For latter growing period (80% flowering to harvest) it showed negative values mostly because of shading of leaves, balls including seeds, which is a normal feature of this crop.

5.3.3 Nodulation and root studies

Number of nodules $plant^{1}$ and its resultant dry matter

were found to be enhanced due to P_2O_5 at all levels from 60^{th} day onwards.It was noted that, as P_2O_5 dose increased, number of nodules and nodule dry matter significantly increased upto 50 kg application ha^1 .Further dose (75 kg ha^1) did not prove its superiority over this level (Table 14 and 19). Beneficial effects of P_2O_5 in increasing nodulation were reported by Norman (1959); Gates (1970); Olsen and Moe (1972); Gates (1974); Gates and Wilson (1974) in *S. guianensis* cv. Schofield, *S. humilis* and *S. hamata;* Singh and Singh (1980); Savastano et. al. (1985), Mariyappan et. al. (1987) in various *Stylosanthes* species. Observations made by Mohd. Saleem and Von Kaufmann(1986) were also in the same line as in the case of *S. guianensis* cv. Cook and Schofield. Whereas in respect of *S.hamata* cv. Verano, they did not observe significant response of P_2O_5, though P_2O_5 is known to stimulate nodulation always. In the present study also, the response of p2o5 was observed upto 50 kg ha^{-1}, perhaps this might be due to minimum requirement of P_2O_5 for optimum nodulation as stated by Munns and Mosse (1980). Nodule dry matter $plant^{-1}$ followed similar pattern as that of nodule production. Gates (1970); Gates (1974); Gates and Wilson (1974); Singh and Singh (1980) in *S. humilis,* Mariyappan et. al (1987) also reported an increase in nodule dry matter due to P_2O_5. Results further revealed that, in 1994-95 both these characters were improved significantly upto 25 kg ha^{-1} and further doses did not show influence over their respective lower doses at 60^{th} day. During 1995-96, the significant increase was recorded upto 50 kg ha^{-1} only, which might be because of residual soil P left in the first year.

The root dry matter $plant^{-1}$ was progressively increased with P_2O_5 application at all growth stages, except at seedling stage. Higher

dose at 75 kg ha^{-1} was superior over 0 and 25 kg application, but did not show supriority over 50 kg at 60th day. However, at 90th and 120th day, each increase in input level increased root dry matter significantly over preceeding level upto 50 kg P_2O_5 ha^{-1} (Table 20 to 22). Optimum availability of P_2O_5 and its reflection on enhancement of root system might have increased root dry matter in this treatment. Exploitation of soil by plant roots due to superphosphate and increase in root weight due to phosphate was indicated by Fisher (1970 a), Gilbert et. al (1989 a) in *S. humilis* and in *S. viscosa* CPI 34904 respectively.

5.3.4 Flowering and maturity

Phosphate application initiated early flowering and it was significantly delayed in the control treatment (Table 23.). The observation made by Fisher (1970 a), Robinson and Jones (1972), are also identical. Maturity of stylo was, however, not affected by P_2O_5 and was attained more or less at the same time in all the treatments (Table 24). This is in tune with the findings reported by Gilbert et. al (1989) in *S. guianensis, S.scabra* cv. Seca and *S. viscosa* CPI 34904.

5.3.5 Yield contributory characters and yield

Inflorescence density (number of balls) was positively related to P application (Shelton and Humphreys, 1971) and was significantly increased with increasing levels of P_2O_5 upto 50 kg ha^{-1}, over their lower levels. Efficient resource utilization might have increased number of balls plant^{-1} at this level. However, Khara et. al. (1990) did not observe significant influence of P_2O_5 on inflorescence density, but reported an increase in floret

number inflorescence^{-1}.Because of more number: of balls at 50 kg ha^{-1}, there their resultant weight was also higher at this level (Table 25).

Number of seeds ball^{-1} were not influenced by graded levels of P_2O_5. Similarly, the weight of seeds ball^{-1} also remaned uneffected due to P_2O_5 (Table26).Seed yield plant^{-1} was significantly increased by increasing rates of P_2O_5 upto 50 kg ha^{-1} application (Table 27). This was due to additive effect of more number of balls plant^{-1} and their resultant weight,which collectively increased seed yield plant^{-1} in this treatment.Reduction in yield plant^{-1} beyond this level attributed to less number of balls and their weight.The seed yield ha^{-1} is a complex output and is affected by large number of factors such climatological paramters, cultural practices and nutrient supply, which inturn directly or indirectly affect the seed yield. Significant increase in seed yield was noticed due to P_2O_5 application throughout the study. With every successive increase in input level, there was significant increase in seed yield ha^{-1} and was maximum at 50 kg application. The increase in seed yield was observed to the tune of 37.86, 59.18 and 52.90 % at 25, 50 and 75 kg ha^{-1}, respectively over unfertilized treatment (Table 28). This increase in seed yiled yield may be attributed to increase through the path way in plant, leaf area for more light interception and photosysthesis, dry matter accumulatioin, stronger yield attributes (number of ball, weight of balls plant^{-1}) and optimum availability of P_2O_5, which collecively resulted into higher seed producion at this level. Shelton and Humphreys (1971) in *S. humilis;* Rai and Kanodia (1980) and (1982) in *S. humilis* and *S. guianensis;* Mohd. Saleem and Von Kaufmann (1986) in *S. guainensis* cv. Cook, Schofield and *S. hamata* cv. Verano; Khara et. al. (1990) in *S. hamata* cv. Verano also indicated an increase in seed

yield due to P_2O_5. In the present study, it was noted that, there was slight decrease in the seed yield to the tune of 3.94%, when P_2O_5 was applied more than 50 kg ha^{-1},which might be due to lower inflorescence density $plant^{-1}$ and finally resulting into lower seed yield. This is in confirmation with the findings reported by Kanodia et. al. (1985) in *S. humilis, S. scabra* E.C 40289, Wherein yield level was reduced by 3.87% due to 80 kg P_2O_5 ha^{-1}.

Straw yield ha^{-1} was significantly increased with every increase in P_2O_5 over its preceeding level upto 50 kg (Table 29). Optimum resource utilization and thereby increase in various growth attributes (stem diameter, number of branches and dry matter accumulation $plant^{-1}$) ultimately reflected into significant increase in straw yield. Bruce and Teitzel (1978), Hewitt (1981), Gill and Patil (1985), Singh (1985) reported similar increase in straw yield upto 40-50 kg P_2O_5 ha^{-1}. Whereas, Gilbert and Shaw (1980), Impithuksa and Rungrattna Kasin (1989), Keerati-Kosikorn et. al. (1987) observed an increase in the dry matter yield of *S. humilis and S. hamata* during second year only. On the contrary, Olsen and Moe (1972), Jones(1974), Mcleod (1974), Bruce and Teitzel (1978) reported reduction in dry matter yield beyond 112, 96 and 50 kg P_2O_5 ha^{-1}, respectively in various *stylosanthes* species. Significant response of phosphate was also recorded by Mohd. Saleem and Von Kaufmann (1986) on *S. guianensis* cv. Cook and Schofield, but *S. hamata* cv. Verano remain unaffected even upto 120 kg application also. Fisher (1970 b), however, was of the opinion that, 75% and 90% dry matter yield can be achieved with 250 and 375 kg SSP and subsequent increase was only of the 10% due to addition of 625 kg ha^{-1}. In the present study also, straw yield was though increased upto highest dose of 75 kg P_2O_5,

, but the response beyond 50 kg was non-significant. Anonymous (1984 c) made similar observations in *S. guianensis* cv. Endeavour and Schofield, where in 40 and 80 kg P_2O_5 ha^{-1} did not show significant variation in dry matter yield. From these reports it can be said that, response to P_2O_5 application in stylosanthes perhaps differs with the species and ecological conditions. Significant increase in harvest index was recorded due to P_2O_5 application, which was highest at 50 kg ha^{-1} (Table 29). H.I. is a ratio of seed yield to biological yield and due to higher seed yield at this level, harvest index was found to be significantly higher.

5.3.6 Quality studies

Test weight, protein content and seed germination were significantly improved upto 25 kg application (Table 30 to 32). Better accumulation of carbohydrate as well protein, and their translocation to the productive organs might have influenced test weight significantly. Similar results were reportd by Khara et. al. (1990). Contrary to this, Rai and Kanodia (1980, and (1982) did not observe significant influence of P_2O_5 on test weight in *S. humilis* and *S. guianensis*. Similarly, P_2O_5 application enhanced nitrogen content in seed, which ultimately formed more proteins. This is in agreement with the findings reported by Gates et. al. (1966). However, Singh (1984) reported that, phosphate application had no effect on C.P. content. Whereas, Mohd. Saleem and Von Kaufmann (1986), observed slight increase in the C. P. content to the tune of 1% even due to 120 kg P_2O_5 ha^{-1}. In the present study also, significant increase beyond 25 kg P_2O_5 was not observed. Anonymous (1984 b) also reported like wise in *S. guianensis* cv. Endeavour and Schofield, where in C.P. content was significantly increased due to 40 kg P_2O_5 over

control and further increase upto 80 kg P_2O_5 was non significant. Seed germination mostly depends upon the viability and vitality of the seed. Seed quality was definitely improved by phosphate application and seeds obtained from P1 to P3 showed better germinaiton than those obtained from control treatment. Increase in germination due to P_2O_5 was also reported by Austin et. al. (1969), Rai and Kanodia (1982).

5.3.7 Nutrient concentration and uptake

Nitrogen and potassium contents in plant were not affected by P_2O_5 application at 80% flowering and at harvest stage. Non influence of P_2O_5 on N content was also reported by Fisher (1970 a), Hall (1982), Gilbert et. al. (1992). Similarly, significant influence of P_2O_5 on potassium concentration was not observed by Gilbert et. al. (1989 c). Phosphorus concentration was, however, significantly and linearly increased upto addition of 75 kg ha^{-1} at 80 % flowering stage (Table 33). Tudsri and Whiteman (1977) reported that P content in plant tops is closely related to P application. Similar observations were made by Falade (1973), Gilbert et. al. (1989 b), Mohd. Saleem and Von Kaufmann (1986), Winter (1988), Hendrickson et. al. (1992). Similarly, Gilbert et. al. (1989 a) also indicated higher P content in inflorenscence during peak floral activity. At harvest stage, significant increase in P was recorded upto 25 kg applicaiton and further there was no significant influence upto addition of 75 kg (Table 34.) This may be attributed to decline in nutrient concentration due to dilution effect, shading of top growth and also due to translocation of nutrients to seed. It is a known fact that leaves and inflorescence had higher nutrient contents and about 60% of the nutrients are diverted to inflorescence at the cost of leaf and stem, and that is why,

P_2O_5 treatments from 25 to 75 kg application did not show sgnificant variation in phosphorus concentration. It was also noted that P concentration in plant tissue was relatively higher during 1995-96 than the initial year at both stages. This increase in P concentration might be due to residual effect of P_2O_5 . This is in conformity with the findings reported by Jones (1968), Eng et. al. (1978), Gilbert and Shaw (1980).

Total uptake of N, P, K was significantly increased due to P_2O_5 throughout the experimentation (Table 35.) Each input level under study, proved superior over its lower level and brought significant increase in N and K uptake upto 50 kg applicaiton. Optimum availability of P_2O_5 , better root and shoot growth, increasing trend in plant population, compared to those at 0 and 25 kg, might have collectively resulted into significant increase in N and K uptake at this level. Total uptake of P was linearly and significantly increased and was maximum at higher rate of application (75 kg ha^{-1}). It is a known fact that P_2O_5 application increases cation exchange capacity and enhances better absorption of plant nutrients (Singh and singh, 1980). All above factors, in addition to significantly higher P concentration in plant tissue, had reflected into significant increase in P uptake in this treatment. This is in confirmation with the findings reported by Jones (1974), Bingo and Dacayo (1982), Anonymous (1984 b), Gilbert et. al. (1989 b).

5.3.8 Residual soil fertility

There was no noticeable variation in respect of availbl. N and K, left over in soil due to addition of P_2O_5. Noticeable increase in N status of soil due to P_2O_5 was also not observed by Mohd. Saleem and

Von Kaufmann (1986) in *S. hamata* cv. Verano. Whereas, content of available P in soil linearly increased with increasing rates of P_2O_5 and were maximum at 75 kg applicaiton (Table 36). It is common observation that, increase in biotic activity followed by addition of organic matter leads to increase in availability of plant nutrient mostly due to dissolution of insoluble organic complexex containing plant nutrient. Residual fertility is thus related to addition of nutrient and its availability to crop. Shaw (1978) in *S. humilis,* Mohd. Saleem and Von Kaufmann (1986) in *S. guianensis* cv. Cook, Brito et. al. (1987) in *Alisicarpus* and *Macroptilium* also indicated an increase in soil available P due to its application.

5.3.9 Moisture retention

Soil moisture was not significantly affected by graded levels of P_2O_5, but there was a tendancy of depletion in soil moisture in the treatments receiving higher P_2O_5 (Table 37 to 39). Availability of P_2O_5 resulted into better root development, better plant growth and enhanced moisture absorption from the soil to meet the increasing demand of the crop. Probably this might have caused depletion in soil moisture in the treatments receiving highP_2O_5.

5.4 Effect of K_2O

5.4.1 Plant population

Plant stand at initial as well as at harvest (m^{-2} and ha^{-1}) was not influenced due to K_2O (Table 5). This is in conformity with the findings reported by Wendt (1971), Strickland and Greenfield (1988).

5.4.2 Plant growth

Plant height, stem diameter plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1}, leaf area index and dry matter accumulation plant^{-1} did not show significant variation due to K_2O (Table 8 to 12). However, Relative growth rate for dry matter exhibited increasing trend of results with increasing dose of potash for first growing period (Seedling to 80% flowering) and negative values with inconsistant trend for the second growing period (80% flowering to harvest) (Table 13). Non influence of potash on various growth attributes was reported by Rai and Patil (1983) in *S. guianensis,* (1984) in *S. scabra* Vog., and (1985) in *S. hamata,* Balbir Singh (1994) in *S. hamata.*

5.4.3 Nodulation and root studies

The number of nodules plant^{-1}, their resultant dry matter and root dry matter plant^{-1} were not influenced due to K_2O application (Table 14 to 22). Observations made by Gates and Wilson (1974) in this regard are also of the same order.

5.4.4 Flowering and maturity

Significant influence of potash was not observed on flower initiation and also on crop maturity (Table 23 and 24).

5.4.5 Yield contributory characters and yield

Characters, such a number of balls plant^{-1}, weight of balls plant^{-1}, number of seeds ball^{-1}, weight of seeds ball^{-1} and seed yield plant^{-1} which contributed to seed yield per unit area remained unaffected due to K_2O applicaiton. Seed yield ha^{-1} also did not differ significantly (Table 25 to 28).

Wickham et. al. (1977), Shelton et. al. (1981) in *S. humilis,* Standley et. al. (1990) reported similar observation.

Straw yield ha^{-1} was increased steadily with increasing dose of K_2O but significant difference within the treatments were not noticed (Table 29). Eyles et. al. (1974) in *S. humilis,* Javier and Marasigan (1978), Javier et. al. (1979) in *S. guianensis* cv. Schofield, Selton et. al. (1981), Rai and Patil (1983) in *S. guianensis,* (1984) in *S. hamata* reported similar findings. However, Gutteridge (1982) observed an increase in dry matter yield of *S. humilis* at higher rate of 400 kg ha^{-1} as KCl or K_2SO_4 during second year only.

Harvest index also did not show significant variation due to K_2O throughout the experimentation (Table 29).

5.4.6 Quality studies

Test weight and seed protein were was not found influenced due to K_2O (Table 30 and 31). Rai and Patil (1984, 1985 and 1986) in *S. scabra, S. hamata* and *S. viscosa;* Singh (1984) in *S. hamata* cv. Verano reported similar results, wherein, Crude protein content remain unaffected due to K_2O. However, seed germination was significantly improved due to 60 kg application over no fertilizer (Table 32).

5.4.7 Nutrient content and uptake

Significant influence of K_2O was not observed on nitrogen and phosphorus concentration in plant tissue at 80% flowering and also at harvest. This is in tune with the findings reported by Bruce and Teitzel (1978)

in *S. guianensis*. But, there was significant increase in the concentration of potassium at every increase in its level, over preceeding level and reached to maximum at 180 kg application at 80% flowering stage (Table 33). At harvest stage, K contents were significantly higher at 60 kg K_2O over no application (Table 34). Increase in K contents due to K_2O were reported by Brolmann and Sonoda (1975) in *S. guanensis;* Coelho and Blue (1980) in *S. guianensis, S. viscosa, S. fruticosa, S. hamata* and *S. scabra;* Shaw and Andrew (1979) in *S. humilis;* Monteiro et. al. (1982) in *S. guianensis;* Werner (1982) in *S. guianensis* cv. Schifield, *S. hamata;* Sanzonowicz and Vargas (1984). The differences in K content beyond 60 kg K_2O could not be observed because of shading of above ground biomass, which may be cosidered as rich in nutrient content.

Beneficial effects of K_2O applicaiton were recorded on total uptake of N, P, K, which found to be increased at higher rate of input application. Nitrogen uptake was significantly higher at 120 kg K_2O over no applicaiton. The uptake of P was also significantly higher at his level over control treatment, but maximum dose of 180 kg proved superior over 60 kg application also and remained at par with 120 kg level. Potassium uptake increased significantly with each increase in K_2O level over its lower level upto 120 kg ha^{-1} (Table 35). This increase in total uptake attributed to balance nutrition of the plant and ease of availbility. In addition to this, increasing plant population, comparatively better crop growth, higher nutrient concentration also collectively resulted into increase in the total uptake. This is in conformity with the observations made by Sanzonowics and Vargas (1984).

5.4.8 Residual soil fertility

Available nitrogen and phosphorus left over in soil did not show much variation due to K_2O, but were increased with a small magnitude, with increasing K_2O levels. This indicated that, K_2O helps in maintaining, N and P status of soil, which might be due to addition of origanic matter in the form of plant tissue and microbial tissue. The residual K status of soil was linearly and significantly increased by graded levels of K_2O. With each successive increase in K_2O dose, there was significant increase in the residual K over its preceeding dose and was maximum in the treatment receiving higher potash (180 kg ha^{-1}) (Table 36). It is normally observed that, residual status of nutrient, is always found to be improved due to its addition. Thus, it may be stated that, where addition was higher, residual soil status was significantly higher and the results in respect of K substantiated this observation.

5.4.9 Moisture retention

Graded levels of K_2O had no significant influence on soil moisture (Table 37 to 39). This observation was more or less similar to that recorded in respect of effect of P_2O_5.

It appears from the foregoing discussion that, soil under experimantation did not suffer from K_2O deficiency and contained enough amount of available K_2O. The added K_2O therefore failed to exhibit its influence on various growth and yield attributes, as initial K_2O in soil was sufficient to meet the requirement of crop under investigation.

5.5 Interaction

5.5.1 Sowing time x P_2O_5 levels

Significant influence of various sowings and levels of P_2O_5 was recorded on seed yield Plant^{-1}. During 1994-95, 28th June sowing in combination with 50 kg P_2O_5 ha^{-1} gave significantly higher seed yield plant^{-1}, which was similar to the seed yield obtained in 13th July at the same rate of P_2O_5 fertilization. Favourable climatic conditions, higher growth period and optimum utilization of P_2O_5 resulted into better seed production in both the treatment combinations. During 1995-96, the seed yield Plant^{-1} was observed to be maximum in 13th August, when fertilized at the same level of P_2O_5 (Table 27 a). Comparatively less plant popultion, less competition amongst plants and optimum availability of nutrients and moisture, which inturn yielded more seed plant^{-1} in 13th August with 50 kg P_2O_5 application. Pooled results, however, exhibited significantly more seed production plant^{-1} from first sowing (28th June) at 50 kg P_2O_5 , which was statistically equal to the yield level of 13th July sowing at the same rate of phosphate applcation (Table 27 b).

Seed yield ha^{-1} was significantly higher in 28th June sowing along with 50 kg P_2O_5 except during 1995-96, when it was similar to that obtained from 13th July sowing at the same level of P_2O_5 application (Table 28 b). Higher plant popultion unit^{-1} area, higher seed yield plant^{-1} and optimum availability of P_2O_5 resulted into higher seed production ha^{-1} in 28th June sowing. During second year, though the seed yield plant^{-1} was higher in delayed treatments, but because of tremendous increase in plant popultion there was significantly higher seed yield ha^{-1} in this treatment combination.

Straw production ha^{-1} was significantly increased due to early sowings and P_2O_5 application. Sowing on 28th June produced significantly more straw when fertilized with 50 kg, over lower levels. However, this yield level was similar to that recorded in 13th July sowing, at the same rate of input application. This increase in straw production probably be attributed to, optimum availability of P_2O_5 and increasing trend in plant population, which collectively resulted into higher straw production in these treatment combinations (Table 29 b).

5.6 Regression analysis

Production function

The optimum levels of P_2O_5 computed for 28th June, 13th July, 27th July and 13th August sowings were observed to be 51.56, 49.77, 51.53 and 42.91 kg P_2O_5 ha^{-1} respectively. The corresponding yields predicted at these levels were 2.734, 2.535, 1.609 and 1.036 q ha^{-1} at respective sowing treatments. On the contrary, seed yields predicted at maximum input levels did not vary much to those predicted at optimum input levels in the respective sowings (Table 40).

The predicted seed yields ha^{-1} were comparatively higher at 50 and 75 kg P_2O_5 in all sowing treatments. However, response to application of 25 kg was higher, which was in the order of 0.795, 0.668, 0.317 and 0.243 q ha^{-1} in 28th June, 13th July, 27th July and 13th August respectively. When P_2O_5 dose was maintained at 50 kg ha^{-1}, the response was found to be moderate and was to the tune of 0.342, 0.278, 0.170 and 0.116 q ha^{-1} respectively. But with increasing P_2O_5 dose to 75 kg ha^{-1}, the response

was greatly decreased to 0.024 q ha^{-1} in 27th July, and even to negative (-0.109 q ha^{-1}) in 28th June and 13th July as well as (-0.012 q ha^{-1}) in 13th August. Observations made by Kanodia et. al. (1985) were also in the same line, wherein the response of P_2O_5 was maximum upto 40 kg application and decreased subsequently with addition of 80 kg. Similar response to kg^{-1} of seed to kg^{-1} of P_2O_5 was noted in all sowings (Table 41).

5. Economic of seed production

Sowing on 28th June gave maximum net return ha^{-1} (Rs. 2392.01) and B.C. ratio (1.18) at cost 'A' during 1994-95. This was followed by 13th July sowing as B:C. ratio was concerned (1.16) (Table 46). This is because of higher yield potentiality of these treatments, which ultimately resulted into higher pofitability during this year. Similar observations were reported by Singh et. al. (1994) under normal sowing. However, during 1995-96 none of the treatments proved to be profitable because of comparatively lower seed yeld than the first year.

Maximum net return ha^{-1} at cost 'A' and 'B' (Rs. 2736.08 and 575.33) as well as B:C. ratio (1.27 and 1.04) was obtained at 50 kg P_2O_5 , as compared to other levels in 1994-95 (Table 47) Rai and Kanodia (1980) also reported maximum profit with application of 20 kg N x 60 kg P_2O_5 in Townsville stylo. During 1995-96, in all treatments profitability was reduced to negative. This was mainly due to drastic reduction in the seed yield.

In the absence of potash, net return ha^{-1} and B:C. ratio (Rs. 1498.19 and 1.16) was highest, followed by 60 kg ha^{-1} (Rs. 1489.39

and 1.15) at cost 'A' during 1994-95 (Table 48). In the present study, K_2O at all levels did not responds to seed production. Probably this might be due to enough content of K_2O in soil to meet the demand of the crop. In 1995-96, because of less seed production at all levels, gain was reached to negative values.

Pooled results at all sowings and at all levels of P_2O_5 as well as K_2O showed net loss at both costs. This is because of less seed production in the year 1995-96, which totally reflected on over all seed production of the crop. On the contrary, the cost of production could not be minimised to that proportion, which was 23% more in 1995-96 compared to the first year (Table 4 b). In the present study, it was observed that, out of total cost, 73.80% in 1994-95, and 97.50% during 1995-96 was incurred on human energy, which could not be decreased (Table 4 b). Singh et. al. (1994) reported similar observations of major expenditure on human energy in cultivation of stylo.

5.7.1 Sowing time X P_2O_5 levels

In all sowings, except 13th August, P_2O_5 at the rate of 50 kg ha^{-1} resulted into highest net return and B:C. ratio at cost 'A' during 1994-95. However, at cost 'B', it was higher in both former treatments (28th June and 13th July) at the same level of P_2O_5 (Table 49 to 52). But, amongst these 28th June sowing with 50 kg P_2O_5 ha^{-1} proved to be more profitable. In 1995-96 and in pooled data, all sowings from 28th June to 13th August, at all levels of P_2O_5 did not give profit. This is due to drastic reduction in seed yield during 1995-96 and its reflection on overall seed production.

CHAPTER - VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

An agronomic investigation entitled " **Effect of sowing time and levels of phosphorus and potash on seed production in *Stylosanthes hamata* (L.) cv. Verano"** was conducted at Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi during 1994-95 and 1995-96. The experiment was laidout in split plot design, with four sowing dates, and four levels of P_2O_5 and K_2O each. Sowings were considered as main treatments, because of their pronounced effect on growth behaviour and yield potential of a crop and were done at four different time from last week of June to mid August (Last week of June, mid July, last week of July and mid August). Phophorus has a great inportance in carbohydrates, fat metabolism, energy transformation, root and nodulation and was tried as sub treatments at the rate of 0, 25, 50 and 75 kg ha^{-1}. Potash was included even though the fact that, soil under study was medium high to high in available K_2O, to improve persistency and tolerance to disease, at the rate of 0,60, 120 and 180 kg ha^{-1} in the same treatment. A common dose of 20 kg nitrogen and full dose of P_2O_5 and K_2O ha^{-1} (as per treatments) were applied at sowing time during first year. In subsequent year, P_2O_5 and K_2O were applied after commencement of rains

6.1 Soil and season

The soil of the experimental field was sandy loam and contained 209.52, 10.33 and 241.83 kg ha^{-1} available N, P, K during first year and 229.14, 13.81 and 281.21 during the second year, respectively.

In 1994-95, total rains, 528.5 mm received in 37 rainy days, were less than the normal but were well distributed throughout the growth period. In 1995-96, total precipitations were 837.10 mm received in 49 rainy days, were erratic in nature and affected growth and flowering behaviour of the crop. Variation in temperature and plant population also played a important role on growth rythum and yield attributes. The season of 1994-95 was more favourable because of well distributed rains and congenial temperature conditions, which resulted into better seed production compared to 1995-96. In addition to above, evenly distributed plant population, might have also helped in increasing seed yield during initial year.

Besides yield data, studies on plant height, stem diameter, number of branches, dry matter accumulation, leaf area ($plant^{-1}$)and leaf area index were undertaken. Some of these observations were used to analyse growth behaviour of the plant with the help of RGR. Yield contributing characters like, number of seeds $ball^{-1}$, weight of seeds $ball^{-1}$, weight of balls $plant^{-1}$, seed yield $plant^{-1}$ and seed qualitative parameters such as test weight, protein content and seed germination were also recorded. Chemical analysis of soil and plant was carried out to assess nutrient concentration, their uptake and residual soil fertility. Flowering behaviour and crop maturity were also studied.

Emphasis on economic analysis was given and optimum input levels as well as benefit-cost ratio was worked out.

The present study was conducted under two variable situations of sowing, as seeding during first year and under perennial behaviour as well as regeneration from soil seed pool during second year. The plant stand as well as various growth attributes showed great variation during both the years. The data of two respective years was pooled, analysed and results are presented accordingly.

Sa lient findings recorded during the course of study are summarised below :

SUMMARY

6.2 Crop stand and growth in relation to treatment variables

Plant population was nearly eight times higher in 1995-96, compared to that during 1994-95. Sowing on 28th June and 13th July, had significantly more plant population throughout the study.

Plant height, stem diameter and number of branches plant^{-1} increased steadily with the age of crop. The rate of increase was maximum between seedling to 80% flowering stage and was decreased subsequently. Both early sowings (28th June and 13th July), attained significantly more plant height at all stages during 1994-95. Stem diameter and number of branches plant^{-1} were also linearly and significantly increased in both these treatments at 80% flowering and at harvest stage. During 1995-96, plant height and

stem diameter did not show significant variation due to sowing treatments. The number of branches plant^{-1} were significantly increased after seedling stage and were more in 13th August sowing, which was at par with 27th July. The leaf area plant^{-1}, LAI, and dry matter accumulation plant^{-1} increased upto 80% flowering stage and found to have decreased thereafter. Sowing on 28th June followed by 13th July, which were equally superior, showed significantly higher leaf area, LAI, and dry matter accumulation plant^{-1} at all stages during 1994-95. During 1995-96, leaf area at all the stages and dry matter accumulation, seedling stage onwards were significantly increased in the late treatments (13th August and 27th July). The LAI followed similar pattern of 1994-95. Relative growth rate measured for dry matter accumulation showed increasing tendancy with lateness in sowing for both growing seasons (viz. seedling to 80% flowering, and 80% flowering to harvest).

Pooled results however indicated ~~indicated~~ equal superiority of both former sowings (28th June followed by 13th July) in respect of plant height, stem diameter, number of branches, leaf area and dry matter accumulation plant^{-1}.

Significant influence of P_2O_5 was not recorded on plant population at both stages throughout the study.

Plant height was linearly increased with increasing levels of P_2O_5, but without noticeable variation. Stem diameter at harvest, number of branches, leaf area and dry matter accumulation plant^{-1} at 80% flowering and at harvest, were significantly increased with each successive increase in P_2O_5 upto 50 kg application (ha^{-1}). The LAI was significantly higher at maximum rate over control and similar to rest of the levels at seedling stage.

Latteron each higher dose increased LAI over each lower dose upto 50 kg ha^{-1}. RGR of dry matter was relatively increased with increase in P_2O_5 levels for both growing periods. 9

Difference due to ~~to~~ K_2O on plant population, height of plant, stem diameter, number of branches, leaf area, dry matter accumulation $plant^{-1}$ and LAI were not marked. Relative growth rate for dry matter recorded numerical increase with increasing K_2O levels for first growing period. But trend was inconsistant for the second growing period.

6.3 Root and nodulation behaviour

Number of nodules and nodule dry matter $plant^{-1}$ increased progressively upto 90th day and declined subsequently. Rate of increase in these characters was maximum between 60 to 90 days and found to be decreased thereafter. Both earlier sowings (28th June and 13th July) produced significantly more nodules and their resultant dry matter during 1994-95. During 1995-96, both these characters were significantly improved in the late treatments of 13th August and 27th July at latter stages of growth than seedling. Root dry matter $plant^{-1}$ increased linearly upto 120th day. The rate of increase was highest between 60 to 90 days and subsequently dropped down. Sowing on 28th June and 13th July had siignificantly more root dry matter during 1994-95. However, during 1995-96, it was higher in the late treatment of 13th August beyond seedling stage, which was at par with 27th July. On pooled basis, both former treatments proved superior in respect of above characters.

Application of P_2O_5 significantly increased nodulation and nodule dry matter $plant^{-1}$ from 60th day onwards. The treatment effects were more consistant during second year. With each increase in P_2O_5 , there was

significant increase in nodule number and their dry matter, upto 50 kg application (ha^{-1}). Root dry matter $plant^{-1}$ was significantly higher at 75 kg P_2O_5 over other levels but was similar to 50 kg application (ha^{-1}).

Influence of K_2O was non significant on nodulation, nodule dry matter and root dry matter $plant^{-1}$ at all stages throughout the study.

6.4 Flowering and maturity

Early sowings (28th June) consumed longer period for FI than delayed sowing during 1994-95. In subsequent year, it was not significantly affected due to various sowings. Crop maturity followed similar pattern as that of FI.

P_2O_5 application hastened FI upto 25 kg ha^{-1} but there was no effect on crop maturity.

Application of K_2O at all levels did not influence flower initiation as well as crop maturity.

6.5 Treatment's impact on yield attributes and yield

The number of balls $plant^{-1}$, weight of balls $plant^{-1}$ and seed yield $plant^{-1}$ were ~~was~~ significantly more in both early sowings (28th June and 13th July) and both late sowings (13th August and 27th July) during 1994-95 and 1995-96 respectively. Number of seeds $ball^{-1}$ were not influenced due to various sowings. Weight of seeds $ball^{-1}$ was significantly higher in 28th June sowing which was at par with 13th July, in 1994-95. During 1995-96, the effects of sowings were non significant. Pooled results indicated superiority of both early sowings which yielded higher seed (2.331 and 2.202 q) and straw ha^{-1} (46.75 and 44.31 q). Harvest index was significantly increased with lateness in sowing.

Application of P_2O_5 upto 50 kg ha^{-1} recorded significantly more number of balls $plant^{-1}$ (211.11), their resultant weight (5.745 g), seed yield $plant^{-1}$ (3.290 g), seed yield ha^{-1} (2.001 q) and straw production ha^{-1} (37.58 q). Harvest index also found significantly higher at this level over control and higher rate, Number of seeds $ball^{-1}$ and weight of seeds $ball^{-1}$ remained unaffected.

Number of balls $plant^{-1}$, weight of ball $plant^{-1}$, number of seeds $ball^{-1}$, weight of seeds $ball^{-1}$, seed yield $plant^{-1}$, seed yield ha^{-1}, straw yield ha^{-1} and harvest index did show significant variations due to K_2O.

6.6 Quality traits

Test weight was significantly higher in 28th June and 13th July sowings in 1994-95, In 1995-96, treatment effects were non significant . On pooled basis, both early treatments proved superior. Protein content did not show significant variation due to sowing. Seed germination was signigicantly improved due to late sowings (13th August and 27th July) during 1994-95. In 1995-96, influence was non significant. Pooled results revealed superiority of 13th August and 27th July sowings.

P_2O_5 application upto 25 kg ha^{-1} increased test weight (3.116 g), seed protein (22.38%) and seed germination (38.70).

Diffierences due to K_2O on test weight and protein contents were not marked. Seed germination was however, significantly improved upto 60 kg addition over control.

6.7 Nutrient content and uptake

Concentration of N, P, K was signifcantly higher in 28th June sowing, which was similar to 13th July, at 80% flowering during

1994-95. During 1995-96, significant variation due to sowings was not recorded. In pooled, N concentration was significantly higher in 28th June, over highest delay of 13th August sowing. At harvest, sowing treatments had no effect on N, P, K contents in plant tissues. Total uptake of nitrogen, phosphorus and potassium was significantly increased due to both early sowings (28th June and 13th July).

Application of P_2O_5 did not influence N and K concentration throughout the study. Phosphorus concentration was significantly increased with each increase in P_2O_5 upto 75 kg application (ha^{-1}) at 80% flowering. At harvest, it was significantly increased with 25 kg dose over control. Total uptake of N and K was found to be increased due to each addition upto 50 kg (113.91 and 80.82 ha^{-1}). However, phosphorus uptake was significantly maximum at 75 kg application (10.05 ha^{-1}).

Effect of K_2O was not significant in respect of N and P contents in plant. Concentration of K was significantly increased with each addition upto 180 kg dose ha^{-1}, at 80% flowering. At harvest, it increased significantly upto addition of 60 kg ha^{-1}. Total uptake of nitrogen was significantly increased due to 120 kg ha^{-1} over no application. Whereas phosphorus uptake was significantly higher at higher rate of 180 kg ha^{-1} which was at par with its lower level of 120 kg. Potassium uptake increased with each increase in K_2O dose upto 120 kg ha^{-1} (79.13).

6.8 Residual soil fertility

Available N was observed to be relatively increased due to early sowing and P and K due to late sowing.

P_2O_5 application did not show significant wavriation in nitrogen and potassium contents. Available phosphorus was significantly increased with increasing levels of P_2O_5 upto 75 Kg (20.55 ha^{-1}).

Effect of K_2O was non significant in respect of available nitrogen and phosphorus. Availabel K was significantly increased due to each increase in its level and was maximum at 180 kg application (330.08 ha^{-1}).

6.9 Moisture retention

Sowing treatments did not show regular pattern in soil moisture upto seedling stage. At 80% flowering, decreasing trend and at harvest, increasing trend was observed due to delay in sowing during 1994-95. In 1995-96 also, there was increase in soil moisture due to lateness in sowing.

Application of phosphate and potash showed decreasing tendancy with increasing P_2O_5 and K_2O levels respectively, but without noticeable variation.

6.10 Optimum input levels for P_2O_5 and K_2O

Optimum input levels for P_2O_5 were observed to be 51.56, 49.77, 51.53 and 42.91 kg ha^{-1} for 28th June, 13th July, 27th July and 13th August sowings respectively.

Effect of K_2O was non significant on seed production The optimum input level therfore could not be worked out.

6.11 Economics of seed production and benefit-cost ratio

Early sowing on 28th June gave maximum net return ha^{-1} (Rs. 2392.01) and net return $rupee^{-1}$ (1.18) investment at cost 'A' during first year. At cost 'B' , all sowings proved to be unprofitable. In 1995-96 and

on pooled basis none of the treatments, either early or late proved beneficial.

P_2O_5 application observed to be profitable during 1994-95 only. Net return ha^{-1} (Rs. 2736.08 and 575.33) and net return $rupee^{-1}$ (1.27 and 1.04) investment was higher at 50 kg ha^{-1} at both the costs i.e. 'A' and 'B' respectively. During 1995-96, P_2O_5 could not increase profitability at both costs ('A' and 'B'). The loss during this year reflected into overall (pooled) profitability of the treatment.

As K_2O dose increased, gross monetary return ha^{-1} found to be increased. But net profit ha^{-1} (Rs. 1498.19) and B:C. ratio (1.16) was higher when no fertilizer was applied, at cost 'A' during first year. In subsequent year and when the data were pooled, there was loss at all levels of with and without potash.

Sowing time x P_2O_5 levels

Sowing on 28th June in combination of 50 kg P_2O_5 ha^{-1} gave maximum net return (Rs. 5293.30 and 2134.30) and net return $rupee^{-1}$ investment (1.38 and 1.13) during 1994-95 at cost 'A' and 'B'. However, in pooled, all sowings, at all combinations of P_2O_5 proved to be uneconomical.

CONCLUSIONS

1. Sowing in last week of June (28th June) and mid July (13th July) were similar in effect and registered significantly higher seed yield ha^{-1} than all sowings. Overall. there was 60% reduction in the seed yield due to delayed sowing of mid August (13th August). Thus sowing between last week of June to mid July proved to be optimum.
2. In general a dose of 49.95 kg P_2O_5 ha^{-1} found to be optimum for the period from 28th June to 13th August.
3. Potash did not affect seed production at all. Seed yield ha^{-1} obtained at all levels were more or less equal to that obtained at without application. It is concluded that, soil rated as medium high to high in available potash (241.83 to281.21 kg ha^{-1}) is good for stylo seed production.
4. Sowing in last week of June with 51.56 kg P_2O_5 and if delayed upto mid July then 49.77 kg P_2O_5 ha^{-1} proved to be optimum for stylo seed production.
5. On the basis of actual seed yield, sowing in last week of June proved to be better for getting higher net return ha^{-1} and B:C. ratio at cost 'A' in first year only. If sowing is delayed then mid July is also suitable as B:C ratio is concerned at the same cost in the initial year only.
6. P_2O_5 application at 50 kg ha^{-1} gave maximum net return ha^{-1} and net return $rupee^{-1}$ investment at both costs ('A' and 'B') in first year only.
7. Net return ha^{-1} and B.Cr ratio was higher without potash at cost 'A' during first year only.

8. Sowing in last week of June, fertilized with 50 kg P_2O_5 ha^{-1} proved to be profitable at both costs during first year only.

9. The present study indicated that, net return ha^{-1} and B:C. ratio was higher in first year only. In subsequent year and on the basis of pooled, stylo seed production was unprofitable. Therefore sowing every year is necessary for getting maximum profit ha^{-1} and net return $rupee^{-1}$ investment.

10. Another important conclusion, though is not a part of study, can also be drawn that, under grazing condition as well as for green fodder production, sowing during establishment year is necessary. In subsequent year, it is not to be done as soil seed pool proved to be enough to generate the population, if allowed for auto seeding after certain period of grazing/cutting.

RECOMMENDATIONS

On the basis of these results, following recommendations can be made :

1. Sowing every year is necessary for maximum and economical stylo seed production.
2. Early sowing upto mid July gives maximum seed yield ha^{-1}.
3. Early sowing in last week of June is profitable as it gave higher net return ha^{-1} and net return $rupee^{-1}$ investment. Sowing upto mid July is also suitable as net return $rupee^{-1}$ investment is concern which was nearer to that of June end sowing.
4. Phosphate application at 50 kg ha^{-1} is sufficient to yield higher seed ha^{-1} and to get maximum net profit and B:C. ratio.
5. Application of potash is not necessary if the soil is medium high to high in available potash.
6. Early sowing (last week of June), with 50 kg P_2O_5 ha^{-1} is beneficial for stylo seed production.

FUTURE LINE OF RESEARCH

The tropical grazing lands suffers due to paucity of suitable legume component to supplement nutritional need of the animals as well as soil enrichment also. *Stylosanthes hamata* cv. verano proved to be quite better for rehabilitation of marginal lands which are otherwise not suitable for arable agriclture (both in respect of productivity as well as environmental degradation). The merit of stylo in such rolling and broken rangelands is further increased by virtue of its adaptability even when the rainfall is about 600 mm. The crop being indeterminate in nature and vegetative growth continues in reproductive phase, shading of top growth (in terms of leaf, balls and seed) is a regular feature of this crop. Moreover, as experienced from the present investigation and information generated thereon, future line of research is suggested on the following points.

1. To know optimum seed rate and plant population unit^{-1} area for maximum seed production.
2. To find out optimum time of harvesting.
3. To know ideal method of harvesting (plant harvesting or plucking of matured flower heads).
4. To find out suitable method of seed collection (sweeping of ground surface, spreading of polythene sheet within rows.)

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